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Trusts and Tariffs.

THERE probably never was a time when fiscal policy and economic method occupied the attention of the several commercial nations so much as they are doing at present. What with sugar bounties in Europe and shipping bounties in America; with proposals for the imposition of countervailing duties in Great Britain and duties on the imports of timber and wheat; with projects for American Reciprocity and for British inter-Imperial Free Trade; with the new German tariff, the new Australian tariff, and the Russo-American tariff war—the minds of political economists, non-economical politicians, statesmen, and faddists are kept busily employed. But the plain business man is, perhaps, more interested in actual and possible developments in and in connection with America than with any of the other movements of the day. There he finds an engrossing study both in Tariffs and Trusts. What American Reciprocity really means has not been made any clearer since we considered the subject in January. Mr. Andrew Carnegie, as a man of business, says that Reciprocity is an easy word to say but a difficult policy to inaugurate. Senator Lodge, as a man of politics, says that Reciprocity is an integral part of the Protective system. What the long-suffering Briton wants to know is whether Trusts are an integral part of the Tariff system. Are the big combines the natural children of Protection? Is a protective tariff essential to the continuance of their existence? Will they, like Lewis Carroll's Boojum, softly and suddenly vanish away before the inrush of Free Trade? These inquiries are momentous to those of us who have been disposed to welcome American Reciprocity as one short step towards Free Trade.

As to the first question, we must reply that Trusts are the natural children of high Tariffs. We quite recognise the fact that in this country the Thread combine has been phenomenally prosperous, the Alkali Union a qualified success, and the Salt Union a dismal failure, without any tariffs. But we have no Trusts or combines in this country comparable with the Steel Trust, the Standard Oil Trust, the Sugar Trust, and other big organisations of America. And these are combinations that would not have been possible except under a high Tariff. They are the children of Protection, and have been fostered, fattened, and flattered by Protection. It may be that they are now able to walk alone, but that does not alter the origin of their strength and prosperity. An American lawyer has recently declared that "the sceptre of empire and the seat of trade are unquestionably passing westward from Britain to the United States," although he is good enough to admit that American predominance does not necessarily mean Britain's decadence. We challenge the use of the word "unquestionably," for we do question the alleged transfer. America was never so much in need of British custom and commercial support as she is to-day, for the sceptre can never be wielded by a country so subject to the slavery of factions and "interests" as is America. Germany has for years dominated the sugar markets of the world, but Germany is now about to lose that dominance, largely because the Kartel, or Sugar Trust or Ring, has been too greedy and too oppressive. Such combinations as that of the Standard Oil Trust of America are both greedy and oppressive, and their term of rule will end some day—perhaps sooner than they think.

It is claimed for the United States Steel Corporation, commonly called the Steel Trust, that it has not sought to oppress either the competitive producer or the consumer, that its policy has been, and is, not to revise prices, but to keep them

down at a moderate level yielding only a fair business profit. So far, the Steel Trust has had hitherto nothing but prosperous times, with an active and ever-increasing demand for its products. When the time of depression comes—when orders are scarce and competition is keen—then we shall be better able to judge whether its enormous powers are exercised for the good or evil of the country and the civilised world. The Steel Trust has not kept out British and German steel for the very sufficient reason that it has not itself enough material to supply all the present and prospective demand. But, handicapped as foreign steel is by freight and duty, there is no doubt that the Steel Trust can shut it out at any time, and keep it out for all time, or as long as the tariff is maintained. It can, moreover, make a handsome profit on a comparatively limited sale at home in times of depression, by maintaining a large output and disposing of the surplus abroad at a loss. This is just what the German Sugar Ring has done, and what the American Steel Ring will do when necessity arises. There is very little room for doubt that in every country the prices which the home consumers have to pay are raised by at least the amount of the Tariff duties. Therefore, the Tariff is a bounty to the home producer, and it is only to choke off outside competition that he gives away any part of the bounty to the home consumer. Now high Tariff is tolerated, even liked, in America, because it is thought that high Tariffs mean high wages. It is only necessary in reply to point to Germany, where the Tariff is high and the wages are low, and to Great Britain, where the wages are nearly as high as in America and where there is no Tariff at all.

When the American workmen realise that high wages are not the necessary consequence of high Tariff and can be maintained without excessive taxation of all the necessaries of life that can be imported, then, in spite of the Capitalists, the day of Free Trade will dawn in America. Will the star of the Trust system at the same time decline? We believe that it will, if the doom of the system is not decreed in the next period of severe trade depression. The Industrial Commission, which has been sitting at Washington and collecting evidence for some months past, heard several witnesses who declared that the time when the iron and steel industries required protection is now past, and that these industries are firmly and deeply enough rooted to flourish without the shelter of a Tariff wall. Others, however, protested, that while the Trusts might now survive without the Tariff, the removal of the Tariff would be adverse to the interests of the country at large, because it would seriously injure the American competitors of the Trust. In their final report to Congress the Industrial Commission say that "the economic advantages of combination and the apparent success of most of the new companies have led many of the ablest business men and economists to the conclusion that combinations have become an established factor in the industrial life of the nation," though they are of opinion that "the fever for organisation which was so evident two years ago seems largely to have run its course." The report dwells on the technical and commercial advantages to be derived by combinations, the economies in production and distribution, and so forth. One also recognises the objections. "There is always the danger of monopoly from the largest combinations, and this danger the people fear. The individual producer, therefore, may count upon having a popular sympathy in his favour. The customer is not likely to avoid dealing with a monopoly at any great sacrifice, but, other things being equal, he will give preference to the independent producer" (until the Trust "scoops the pool"?). As regards the Tariff, the report says: "Removal of the Tariff, even in any single industry, should not be lightly considered. When the Tariff is essential to any industry its removal would doubtless kill not only the combination but the industry itself, bringing upon the country attendant evils. Even if the industry is not killed, if severe pressure is brought to bear, the industrial combination will not be the first victim, but rather its domestic competitors pos-

sessed of less advantages in manufacturing, or less financial strength to withstand competition."

The proposition, then, is laid down that the removal of the Tariff will only abolish Trusts by abolishing the industries affected by them. It is even indicated that the sharpening of foreign competition by the removal of the Tariff would drive the American combines to expand into international combinations, on an even more comprehensive scale than that which dominates the Thread industry in both hemispheres. It is not our purpose just now to consider the legislation which the Commission proposes for the regulation and limitation of Trusts and Combines. What we have to point out is that while the Trusts are the children of the Tariff, both are likely to be sustained so long as the belief exists that both are essential to the industrial prosperity of the country—which, of course, they are not.

American and British Iron Trades.

RAILWAYS are still the greatest of all consumers of iron and steel, notwithstanding the vast quantities of these materials used for bridges, ships, and buildings. This fact is in itself a sufficient reason for the enormous development that has taken place of late years in the iron and steel industries of the United States. That the production of Great Britain has not increased at a similar rate is due to the fact that our principal railways are already built, and that the protective duties established by other countries place our manufacturers at a considerable disadvantage when competing for foreign orders. Moreover, we find a formidable competitor in Germany, and other competitors, small individually but large collectively, in various Continental states.

Competition from the United States, although of sufficient importance to deserve careful attention, is nothing to what it may become should the home demand of that country fall appreciably below the supply. Nature has been particularly obliging to the United States in respect of all the raw materials required for the manufacture of iron and steel, the only exception being the ores of manganese needed in the production of steel. Several states are rich in iron ores and bituminous coal, and anthracite coal is plentiful in Pennsylvania. Lake Superior and Cornwall ores are well adapted for the making of Bessemer and open-hearth steel, while the Connellsville and Pocahontas cokes are probably fully equal to the celebrated Durham coke produced in England. Reliable judges consider that there is no appreciable limit to the supply of rich and pure iron ores in the Lake Superior district; it is an established fact that there are boundless deposits of good coking coal in the regions above mentioned; and many American rolling mills have abundant and gratuitous supplies of fuel in the form of natural gas. In addition to these advantages, the United States can boast of possessing some of the most skilful and enterprising iron and steel makers yet known.

The fact that the United States now account for 37 per cent. of the total production of iron and steel in the world, is only in part due to the bounty of nature, for it is largely the result of legislative action. This statement, which may sound altogether heretical to faithful believers in the specious form of Free Trade practised in this country, is not merely surmise on our part. It is put forward by Mr. Swank, the general manager of the American Iron and Steel Association, as a deliberate statement of fact. He has recently stated, in a report to the United States Geological Survey, that through the operation of protective policy the home market has been preserved for the home producers of iron and steel and of all articles made from these metals. Again, the construction of railways has been largely encouraged by the land grant and the homestead systems. But, as Mr. Swank says, many of these railways could never have been built if protective tariffs had not built up, first, the iron-rail and then the steel-rail industries, for in early days the prices of foreign makers were absolutely prohibitive. Both of the industries in question had at the start to struggle against outside com-

petition, because the duties first imposed were not sufficiently protective. Ultimately, however, control of the market was obtained, production increased enormously, and prices were then reduced.

The construction of railways was followed by the discovery and exploitation of iron and coal mines that would otherwise have remained dormant, and so the whole country was enriched. The influence of the above-mentioned policy upon the iron and steel industries in America may be judged by the following figures. The first experimental steel rails were made in Chicago in 1865, and no more than 259,699 tons were rolled in 1875, yet in 1879 more Bessemer steel rails were produced in the United States than in Great Britain. In 1881 the Americans made 1,187,770 tons of steel rails, and in 1887, 2,101,904 tons; while the maximum output of Great Britain occurred in 1882, when 1,235,785 tons were produced. The statistics for 1900 are even more striking, for the United States then made 2,383,654 tons, and Great Britain only 759,844 tons of Bessemer rails. In the year 1890 the United States first caught up Great Britain in the production of pig-iron; between that year and 1897 the occupancy of the premier position alternated from one country to the other, until it was finally captured by the United States. In 1900 the production of pig-iron in the latter country was 13,789,242 tons, and in Great Britain only 8,959,691 tons. As for the production of steel of all kinds, the figures for 1900 were—United States, 10,188,329 tons; Great Britain, 5,050,000 tons. It may be remarked incidentally that Germany, our most formidable opponent next to the United States, produced in 1900 over 8,350,000 tons of pig-iron and over 6,235,000 tons of steel. Other nations are making proportionate advances, and in the aggregate their output constitutes a very considerable quantity.

A striking fact is that foreign nations, and even individual states of the British Empire, all adopt protective duties, so that we suffer from the peculiar and self-imposed handicap of fighting the whole world with one hand tied, so to speak. In spite of this our iron and steel trade appears to be in a position of extreme prosperity, and the cry on all hands is that deliveries can nowhere be secured within reasonable time, owing to the great pressure of orders. Moreover, we are still securing by open competition a large share of the trade from other countries.

Notwithstanding these favourable appearances, we are not entirely satisfied with the position. If orders are so plentiful, surely it is the duty of our iron and steel producers to extend their plants so as to cope with the demand, and by the aid of largely increased output to further reduce the cost of production so as to secure a still greater measure of support from foreign markets. The fact appears to be that manufacturers hesitate to incur heavy outlay because present prosperity may at any time be followed by depression. Imperial and Local Government authorities refuse to support home industries, and foreign markets may at any time be closed by prohibitive duties, because the principle of reciprocity is neglected. Hence, feelings of distrust and uncertainty are inevitable. It seems vain to hope for a revision of fiscal legislation on rational lines. The present system, which is supposed to rest on a Free-Trade basis, seems to consist in taxing imported articles that are not, and in many cases that can never be, produced in this country, and in letting in free of duty manufactured articles of the kinds that constitute staple industries of the country. So choice an example of "topsy-turveydom" would certainly not be permitted to remain if our ruling classes consisted of business men. Even if we cannot at present have a general common-sense tariff, there ought to be exceptional facilities for the encouragement of trade between different states of our Empire. Something has been done in this direction within recent times by the one practical man of action in his Majesty's Government, and probably more may be in contemplation; but there seems to be a general disposition on the part of the Administration to favour other countries, wherever possible, to the detriment of British states.

The importance of altering this fossilised policy becomes evident when we examine the figures relating to the development of

the iron and steel industries in Greater Britain. Taking first the statistics of the Canadian iron trade, we find that greater progress has been made in 1900 and 1901 towards the development of the iron and steel industries than in any previous years. The production of pig iron in the Dominion amounted to 86,000 tons during 1900, as compared with 37,829 tons during 1895. On December 31, 1900, there were ten completed furnaces in Canada, and four additional furnaces were in course of construction at Cape Breton, by the Dominion Iron and Steel Company. During the first half of the year 1901, the production of pig iron in Canada amounted to no less than 95,024 tons thus exceeding by more than 9,000 tons, the output of the whole previous year. In 1900, the production of Bessemer pig iron was 3,781 tons, whereas in the first six months of 1901, it amounted to 17,577 tons.

It is freely admitted, even in the United States, that the steel industry of Canada is in a state of preparation for important results, and that the fulfilment of great expectations is apparently near at hand. Various steel-making plants are in a forward condition, the most important advances being the open-hearth installation of the Dominion Iron and Steel Company, comprising ten 50-ton furnaces of the Campbell tilting type, in which both acid and basic steel will be produced. A part of this plant will probably be in operation during the early part of the present year, and the rolling mills are to be suited to the production of blooms, slabs, billets, and rails. Early in 1900, Messrs. W. Kennedy & Sons, Ltd., of Ontario, erected a two-ton Tropenas converter for the manufacture of steel castings, and this plant has been in operation since May of the same year. At the end of 1900 there were 18 completed rolling mills and steel works in the Dominion, and the following is a record of steel turned out in various forms: Open-hearth steel rails, 700 tons; structural sections, 4,674 tons; cut nails, 5,231 tons; plates and sheets, 2,100 tons; miscellaneous, 87,984 tons. The figures for 1901 are not yet available, but, as already shown, they must be more than double those stated above. The allied industry of coal mining presents equally gratifying figures, as the total production in 1900 was 5,597,832 tons, or about one-quarter of the whole amount produced in Belgium. We might refer to the statistics afforded by other parts of the Empire, but enough has been said to show that very considerable developments are taking place, but in the Mother Country we are doing nothing to help Colonial industries by reducing the advantages now offered to foreign competitors. If members of the Imperial Parliament could be persuaded to drop once and for all the squabbles about purely party politics, on which their energies are now dissipated, they would have time for considering measures by which the prosperity of the British Empire could be wonderfully advanced.

It is too much the fashion for Americans and foreigners to speak of England alone, forgetting to mention Great Britain and Greater Britain. Personally, we are quite satisfied as to the ability of Great Britain herself to hold her own among the nations of the world; but beyond this, we maintain that we are still a young people, and that, unless thwarted by action due to obsolete writings on Conservative or Liberal slates, or on both, we shall establish records of industrial progress fully equal to any yet attained by any country in this or the other hemisphere of the world.

The Rating of Machinery.

BRITISH manufacturing industries are possessed of wonderful vitality. They have to withstand competition from countries where trade is assisted by protective duties or bounties, or by both of these pleasing devices, and where the crippling effects of trades unionism are unknown. British manufacturers have not only to fight against adverse conditions such as these, but also against the tendency exhibited by some Government departments and by many local authorities to favour foreigners by waiving restrictions rigorously maintained in this country. Moreover, British firms are most seriously

hampered by the outrageous conduct of local bodies, such as the London County Council, in aiding and abetting trades union tyranny.

As if these burdens were thought to be insufficient for the repression of industrial enterprise to a proper extent, a wise Legislature devised the Rating of Machinery Bill. This measure is not only in itself highly impolitic, but many local authorities seek to utilise its provisions in a manner that is utterly unjust. The Machinery Users Association, to whose good work previous allusion has been made in our columns, exists for the purpose of securing fair treatment for the industries of Great Britain, and it is worthy of note that its views have been most favourably reported on by the Royal Commission on Local Taxation.

Just at the present moment there is an especial reason for supporting the patriotic action of this Association, for two important legal decisions adverse to manufacturers have recently been made. In the first case, it was held by the High Court that movable hydraulic cranes on a dock quay were to be rated, because when in use they were "attached to the premises by means of a flexible tube" for the supply of water. The far-reaching and disastrous results that may be expected from this decision, concerning appliances "attached" to the premises by a flexible tube or wire, are suggested by the second case. In this it was decided by the Recorder of Northampton, at the instance of the local assessment committee, that all tenants' machinery and chattels, including sewing machines, must be separately valued, and a percentage on their capital value added to the rateable value of the buildings in which they are placed. Not content with this verdict, the Northampton Union Assessment Committee now wish to rate the patent rights and royalties on such machines by adding a percentage on their capital value to the rateable value of the buildings.

The Committee of the Machinery Users' Association have decided, after mature consideration, that the second case raises so important and vital an issue that it must be carried for final decision to the House of Lords. They therefore invite the support of all British manufacturers to enable the Association to prosecute the appeal to the best possible advantage, and we have great pleasure in directing attention to this most laudable movement.

An even more laudable crusade would be one for the removal of the numerous disabilities that now cripple various British industries. It is bad enough that the nation should have to pay through the nose for the scandalous waste and incompetence exemplified by the great spending departments of the State, but it is still worse that the means of paying should be reduced by continued assaults upon the true source of Britain's wealth.

The Future of the Panama Canal.

THE more this question is considered, the more fatuous appears England's policy, or lack of one. To the projected ship canal through Lake Nicaragua, regarded by an overwhelming consensus of American expert opinion as a piece of stupendous folly, almost certain to result in national loss and humiliation, there is but one possible alternative. Of this the United States have secured by adroit manipulation, which would reflect credit upon the shrewdest of commercial houses, an option of purchase at a price fixed by their own agents, and suggesting a valuation of scrap iron rather than of a going concern; for such, in part at least, is the property of the vendors. Though it pronounced the Nicaragua project feasible, and under certain conditions the better suited for American exploitation, the Isthmian Canal Commission avowed—it could scarcely do otherwise—many technical preferences for the partially completed Panama enterprise. Against the latter could only be urged—first, M. Hutin's hesitation to fix an amount for which the New Panama Company would undertake to transfer to the United States, free from contestation of any sort, all its rights and properties; and secondly, doubts as to whether terms equally favourable to the United States could be obtained

from the Republic of Colombia as from Nicaragua. The attitude of the Commission throughout the negotiations in Paris and Washington was consistent and business-like, not a little strengthened, perhaps, by the conviction that the Company must eventually succumb to the pressure of circumstances. The Commission declined to consider the amount of 109,141,500 dols., which had been suggested by M. Hutin as "a basis for discussion," as other than a definitive offer, and insisted, despite legitimate protests, in so treating it in its report. The Commission at the same time submitted a calculation of the work already accomplished, which, it admitted, would be of value in connection with the plan for completion recommended by itself. The total quantity of excavation thus taken into account was 39,586,332 cub. yds., valued at 27,474,023 dols. The Commission also estimated at 6,850,000 dols. the value of the Panama Railroad shares held by the Canal Company, and at 2,000,000 dols. the value of Company's maps, drawings and records—to which it was pleased to add 10 per cent. to cover omissions, "making the total valuation of the Panama Canal 40,000,000 dols." Such an amount is of course ridiculous, as compared with the volume of misapplied energy and the £70,000,000, more or less, lost directly or in consequence of the extragavance and maladministration of the De Lesseps' Company. In the end, the shareholders in the present company were driven to a corner, and in hot haste declared themselves prepared to sell, even on the above-mentioned terms. The Isthmian Canal Commission then issued a supplementary report reversing all its original findings, dwelling upon the many manifest advantages of the Panama route, and declaring it to be altogether the most practicable and feasible for the construction of an inter-oceanic canal, "to be under the control, management and ownership of the United States."

The Republic of Colombia, which has so long and frequently bled the holders of its canal concessions, also played its anticipated part in the little game by outbidding Nicaragua in its proffers to the United States of land and territorial jurisdiction, so turning the first sod of the grave of its independence. Henceforth, British commerce in the isthmus is threatened with extinction, and so also will it be in the markets of the western littoral of South America, unless strenuous efforts, of which to-day there is no sign, are made to save it. Although, by the abrogation of the Clayton-Bulwer Treaty, we have as a nation regained our freedom of action in Central America, the right is worthless to us. With Downing Street to play our great rival's game, the nation apathetic, and the much vaunted enterprise of British capital more concerned with Stock Exchange peddling than magnificent and really salutary schemes, Britain has sacrificed an opportunity—more favourable even than that seized by Lord Beaconsfield in November, 1875—of consolidating her commercial and maritime supremacy, now threatened as it never was before. It may suit our present interests, the Isthmian Canal being yet a dream of the future, to ignore American talk about discriminating duties. That, however, need not blind us to the fact that, beneath what we are now pleased to regard as mere words to the "gallery," there is a settled policy. It is well to remember, even to-day, that many Americans favour the Nicaragua route, because, in their opinion, the traditions of Panama are a barrier to the complete realisation of their ideals. This, in large measure, explains the remarkable vote of the House of Representatives on January 9th.

The Standardisation of Locomotives.

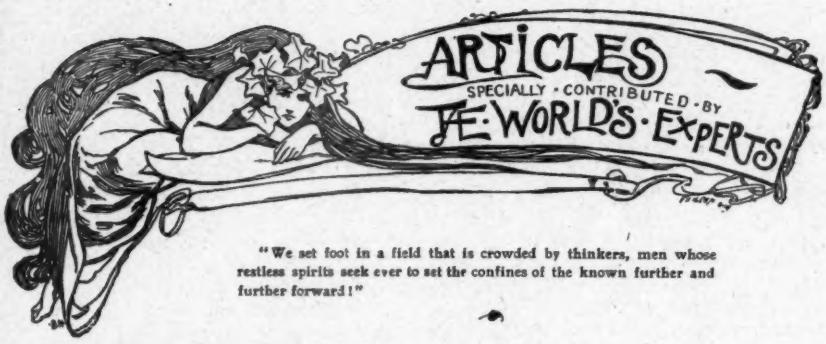
In our January issue the suggestion was made that the Institution of Mechanical Engineers might well take some action with the view of securing uniformity in machine construction, and we then urged that the locomotive building industry was in especial need of a helping hand. Our readers will be pleased to learn that the subject has been promptly taken up by those interested, and the result is the Engineering Standards Committee. The first sitting of this body took place last

month at the Institution of Civil Engineers, and was attended by many well-known consulting engineers, locomotive builders, and representatives of the Indian and Colonial Governments. The principal points brought under consideration were (1) the desirability of standardisation in locomotive construction; (2) whether standardisation should apply to general design, or be limited to points of detail; and (3) the practicability of determining the quality of the various materials to be used in construction. The evidence taken so far by the Committee is from railway locomotive superintendents, who appear to be in favour of standardising tests of component parts, but to be opposed to standardisation as applied to general design. In our previous reference to the subject, we anticipated this objection, which arises from the natural tendency of every railway engineer to think his own design the best. We strongly protest against the suggestion made at the conference that standardisation of design would be of no material benefit in Great Britain. It is no doubt true that most of the great companies make their own locomotives, but they frequently have to buy from outside firms. When such a contingency arises, it is generally found that British makers have no standard types complying with the fancy of the locomotive superintendent, although they may be of thoroughly satisfactory design and in every other respect suitable for adoption. The direct results are delay, foreign competition, and snappy paragraphs in halfpenny papers about the supineness of British manufacturers.

It is to be hoped that when the turn comes of the locomotive builder to offer evidence, a determined fight will be made for the purpose of establishing the complete and effective standardisation of locomotive engines. No half-measures can ever be satisfactory, and the personal predilections of railway officials and others must not be allowed to prejudice an important industry.

The Coal Mines Bill.

ANOTHER preposterous attempt to limit the freedom of coal owners, miners, and others has been rejected by the House of Commons. The Coal Mines (Employment) Bill, happily thrown out by a substantial majority, can only be described as one of the most pernicious attempts ever made to damage British industry. That such a description is thoroughly appropriate may be gathered from a brief inspection of its provisions. The first of these proposed that no male person under the age of 21 years should be employed in any mine below ground for more than eight hours in any consecutive twenty-four hours; and the second proposed that no person should be employed in any mine below ground unless he had been so employed before attaining the age of 18 years. Everyone knows that no class in the whole country is less in need of protection than coal miners, who earn high wages, and work just so long as they choose. Speaking in general terms, it may be said truly, that they earn so much money that idleness becomes a strong temptation, but they would resent any interference of the kind suggested in this Bill; and it must be remembered that restriction of the hours of boys means restriction of the hours of men. Dismissing from consideration what was said in support of the measure by professional agitators, we notice nothing was adduced in its favour beyond mawkish and misplaced sentimentality. The fact is, that the promoters of the Bill want to create a privileged class capable of controlling the coal trade of the kingdom in such a way that, if thought necessary in the interests of their class, the whole industrial work of the country could be stopped until their exactions were complied with The second provision of the Bill was clearly directed against the use of mining machinery, which is even now too little used in this country. Engineers and mechanics cannot learn their trade in coal mines, consequently none of them would be allowed in mines of the future if the promoters of this precious Bill had their way. Wild Irish Members are bad enough, but those are even worse who deliberately hatch plots against an industry which, to quote the words of Mr. Ritchie, "is the life-blood of the industries of the country."



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

Improvements in the Manufacture of Cereal Food.

By J. ADDYMAN GARDNER, M.A., F.I.C., etc.

THE chief object of the miller's art is to treat the wheat grain in such a way as to eliminate as much as possible not only those constituents which are considered less suitable for human food, but also those which exercise any deleterious influence on the quality of bread as ordinarily manufactured, even though in other respects they may have a high food value. In order to understand the nature and composition of these constituents, it will be necessary to describe briefly the structure of a wheat grain.

If we examine a section of a wheat grain, which is really a fruit, we find that it consists roughly, of an envelope known as the bran, enclosing a softer white kernel—the endosperm—and the germ or embryo. The bran is divided into the outer envelopes of the grain and those of the seed proper. The outer envelopes are three in number—the cuticle, epicarp, and endocarp, which together constitute about 3 per cent. of the whole grain. Beneath these comes the first of the envelopes of the seed proper, surrounding both the endosperm and the embryo; this is known as the testa, and contains most of the colouring matter of the bran. Following the testa is a layer of aleurone cells, so called from the proteid they contain, enclosed in a thin membrane. This layer of cells envelopes the endosperm, but not the embryo.

The endosperm is divided up by layers of parenchymatous cellulose into large cells, which are filled with starch granules embedded in gluten, a substance insoluble in water, and consisting chiefly of vegetable fibrin in union with a nitrogenous compound called gliadin. The gluten in bread-making gives to the dough its characteristic adhesiveness and power of forming a spongy mass when carbonic acid gas is generated throughout its interior.

The bran of wheat consists largely of woody fibre, with a considerable proportion of soluble albuminous matter, which is injurious if contained in flour, as it exerts a considerable action on broken starch granules.

The germ is rich in proteid matter, both soluble and insoluble in water, and in fat. This high percentage of fat gives it a tendency to become rancid, and the nitrogenous matter, like that of the bran, has a diastatic action on starch. The object of the miller, therefore, as stated

above, is to treat the wheat in such a way as to eliminate as far as possible the bran and the germ, whose constituents are apt to injure the quality of the flour from a baker's point of view. In modern milling processes the wheat goes through a very complex series of operations, by which it is separated into flours of various qualities and offals. A very complete investigation of the composition both of the intermediate and final products in roller milling has been made in England by Page and others, and in America by Clifford Richardson.

The following analyses illustrate the composition of wheat and of some of the products obtained therefrom. Table I. gives the composition of a few of the products turned out by a certain American firm of millers, and is taken from Richardson's paper. Table II. contains analyses published by various observers, showing the average composition of American wheat, flour, bran, and germ :—

TABLE I.

NAME.	Water %	Ash %	Oil %	Carbohydrates %	Fibre.	Proteids.	Nitrogen.	Phosphoric Acid.	Ratio of Nitrogen to Phosphoric Acid.	Gluten	
										Moist.	Dry.
Wheat as it enters the mill	9·66	1·91	2·61	69·64	1·70	14·18	2·27	·82	2·77	...	...
Baker's Flour	12·18	·62	2·00	69·99	·33	14·88	2·38	·31	7·68	51·21	16·97
Patent Flour	11·48	·39	1·45	73·55	·18	12·95	2·07	·18	11·5	36·14	10·85
Low-Grade Flour	12·01	1·99	3·86	63·26	·93	17·95	2·74	1·16	2·36	10·01	4·26
Bread Flour	12·48	·58	1·87	69·44	·23	15·4	2·46	·31	7·94	51·38	15·87
Cockle Bran	7·71	3·46	3·84	65·46	9·03	10·5	1·68	·83	2·02	...	...
Second Germ	8·75	5·45	15·61	35·19	1·74	32·25	5·32	2·57	1·98	...	...

TABLE II.

NAME.		Number of Analyses.	Water.	Ash.	Oil.	Carbohydrates.	Fibre.	Proteids.	Analyst.
American Wheat.	mean ...	407	10·2	1·9	2·2	71·7	1·8	12·2	Richardson.
	highest .	...	12·5	3·6	3·6	78·7	3·1	18·0	
	lowest...	...	7·7	0·8	1·4	64·8	0·4	7·7	
American Wheat Flour.	mean ...	25	12·5	·06	1·2	74·1	0·3	11·3	Johnson.
	highest .	...	13·6	...	2·0	78·1	1·2	14·1	
	lowest..	...	10·3	...	0·6	68·3	0	8·6	
American Wheat Bran		68	12·4	5·6	3·8	53·5	9·3	15·4	Johnson.
Wheat Germ		4	3·5	4·8	11·5	45·6	2·0	27·6	Richardson.
Wheat Chaff		...	14·3	9·2	1·4	34·6	36·0	4·5	Wolff.

Analyses of the ash of flour show that although smaller in quantity than that from an equal weight of wheat, it is relatively richer in potash and lime salts, though poorer in salts of magnesia. On the other hand, the ash of bran, though larger in quantity, is relatively poorer in potash and lime, but richer in magnesia salts. The outer portions of the grain also contain more phosphates. During the past twenty years certain food reformers have been continually agitating in favour of bread made from flour got by pulverising the whole grain in place of that made from fine flour; their main reason being that as bread is the staple diet of the poorer classes, it should be brought as nearly as possible up to the standard of a perfect food—*i.e.* a food containing such relative quantities of carbohydrates, fat, proteids, etc., as to be capable alone of supplying the needs of an average human being.

From this point of view bread made from fine flour is deficient in fat and proteid, but contains too much carbohydrate matter. An inspection of the analyses set forth in the above tables makes it clear that wholemeal bread would contain a smaller percentage of carbohydrates than white bread from the finest flours, but

would be richer in fat, mineral matter, and proteids; in fact, as far as the latter constituent is concerned, it would be present in very nearly the proportion required for a perfect food. From a purely analytical point of view whole-meal bread is certainly preferable to white.

Chemical analysis, in the conventional sense, however, does not afford us a complete criterion as to the value of a food, for the form in which the various constituents are presented to the digestive juices of the stomach and intestines has a profound influence. Actual experiments on the human subject by various observers have shown that bread made from coarse whole-meal is much less digestible than that from fine white flour. When coarse whole-meal bread is taken some 12 to 14 per cent. is excreted unchanged, but in the case of white bread only about 4 to 5 per cent.

This waste consists chiefly of woody fibre, cellulose, mineral salts, and nitrogenous or proteid matter. Of the various constituents of the original bread, the greatest proportionate waste is in proteids, fat, and mineral matter. As much as 50 per cent. of the ash of whole-meal bread is excreted unchanged, while in the case of white bread only about half that amount. The nitrogenous matter wasted is probably that of the bran, because Gerard, by experiment on himself, showed that aleurone grains passed through the alimentary canal apparently unchanged, perhaps owing to the highly impermeable nature of the cell walls.

The coarse particles of bran in the whole-meal also exert an irritant action on the intestines, thereby promoting peristaltic action, and thus causing a waste of other food which may have been taken along with the bread.

Some of these disadvantages may undoubtedly be minimised by reducing the meal to a fine state of division, but this is somewhat counter-balanced by the greater difficulty in baking a good loaf from such meal.

In addition to the disadvantages mentioned, whole-meal, whether coarse or fine, shows serious defects when baked by the ordinary methods, using yeast as the ferment for producing carbonic acid. This is due to the nitrogenous matter of the bran, the cerealin of which is present in sufficient quantity to cause hydrolysis of the starch to proceed to a serious extent. The excess of dextrin produced in this way causes the dough to become soft and clammy, and, according to Jago, to offer a matrix in which sour and other unhealthy fermentation is apt to proceed rapidly. Whole meal bread has further a tendency to become sodden, and in order to drive off the excess of moisture has to be baked for a comparatively long time, so that the finished loaf has a very thick crust, and even then the interior is often unduly moist. These defects are apparently intensified by the heat in summer, and also by increased fineness of the meal. The flavour of such bread is, moreover, undoubtedly inferior to that of bread made from fine white flour.

Numerous methods have been introduced to obviate these difficulties, not only by modifications in flour manufacture and in baking processes, but also in the form in which the cooked food is presented to the public. Many of these inventions have met with marked success, but it is impossible in the course of this short article to give any detailed description of all. One of the latest, however, presents some features of novelty, and as the product, under the name of Shredded Wheat Biscuit, is being largely manufactured in America by the Natural Food Company, Niagara Falls, N.Y., and has been recently introduced into England, a detailed description may be of interest to our readers. The methods of manufacture and the machinery used are covered by various patents in America, and in England by two patents taken out in 1895 and 1896 by Mr. Henry D. Perky, of Worcester, Massachusetts, U.S.A., under the titles of "Improvements in and relating to Cereal Food or Bread, and the Manufacture of the same," and "Method and Means for the Reduction of Grain to Threadlike or Shredded form, and for the disposition of the same in the Manufacture of Articles of Food," respectively.

The object of the inventions, according

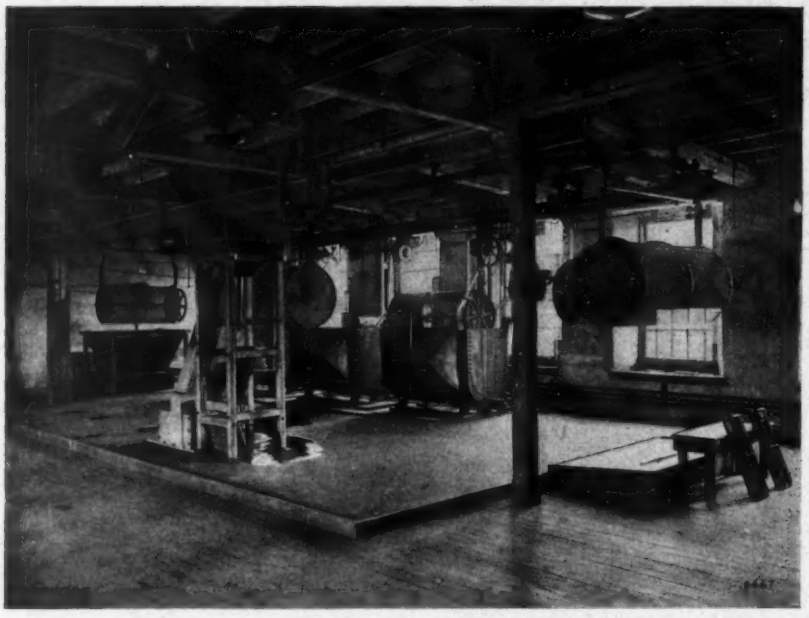


FIG. 1.—SHOWING APPARATUS USED FOR THE BOILING OPERATION IN THE MANUFACTURE OF SHREDDED WHEAT.

to the patentee, is "the economic production of a cereal food or bread which will be wholesome, inviting in appearance, and palatable; such production being accomplished without the addition of injurious properties or compounds, and without taking from the grain any of the beneficial qualities provided by Nature, and presenting the same in convenient form for service as a superior article of food, without the aid of expert or skilled labour now required to produce bread."

The wheat in grain form is first of all mechanically cleaned and thoroughly washed, after which it is boiled for about an hour. This cleaning and boiling removes the extreme outer silicious coating of the grains and any adhering extraneous matter, and destroys any insect life that may be present. It also probably destroys to some extent the diastatic properties of some of the proteids of the wheat, and further aids in preventing any unhealthy fermentation. The wheat grains after this operation are quite soft, can be easily squashed between the finger and thumb, and the interior portions are somewhat watery.

In order to bring the inner and outer portions of the grain into a state of more or less similar consistency for the next operation, it is necessary to allow the wheat to dry for some hours. This drying must not take too long, otherwise incipient fermentation may set in, and the operation is therefore assisted by agitation and spreading out over large surfaces in the drying chamber. The time necessary varies somewhat, but usually twelve to twenty-four hours is sufficient. The boiling is carried on in a revolving wire cage immersed in a boiler, the general arrangement for which is shown in Fig. 1.

The boilers are steam-jacketed half cylindrical bowls, across which, at an interval from one another a little greater than the length of the cage, are fixed transverse

supports, provided with open bearings for the reception of the primal portions of the cage shaft, which project beyond the supports, and carries a toothed wheel. At one side of each boiler, in such a position as not to interfere with the cage being lifted out, is a short power-shaft, having a pinion arranged to engage the toothed wheel of the cage when in position in the boiler. The cylindrical body of the cage is made of strong galvanised wire gauze, the ends being constructed of stout plates to secure it to its shaft. In one side there is an opening provided with a cover. The power-shaft is provided with fast and loose pulleys, and is turned by a band from a line-shaft. The boilers are provided with waste pipes at the bottom.

Above the boilers is an elevated track, upon which runs a carrier provided at each end with a fall and tackle, having at its lower end a hook adapted to engage the end of the cage shaft. Check blocks are used in these falls, so that the cage may be held at any height automatically. In this way the cage may be readily transferred from the feed hopper to the boiler, and from the boiler to the hopper, shown at the end of the room, into which the boiled wheat is discharged. From the latter hopper the wheat passes down an obstructed shoot on to drying frames below. In passing down the shoot, the wheat is thoroughly agitated and aerated, and loses most of its rough moisture. It is then spread out on the frames in the drying room (Fig. 2).

After treatment in the manner described, the interior portions of the wheat grains have such a consistency as to admit of being effectively incorporated with the outer portions in the next operation, and reduced to the form of porous and tender filaments. The wheat is automatically spouted to the hoppers

FIG. 2.—THE DRYING FRAMES.

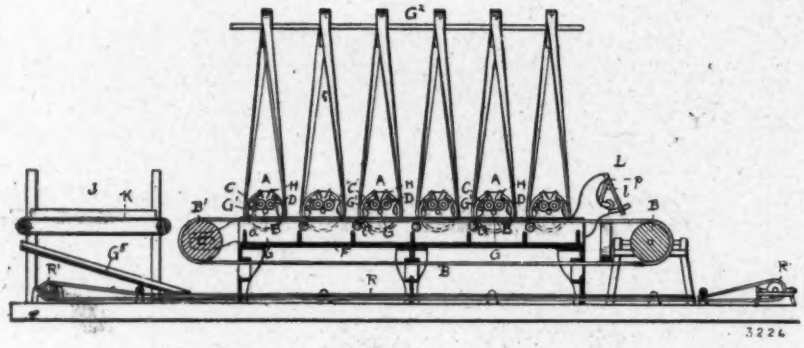


FIG. 3.—GENERAL ARRANGEMENT OF THE SHREDDING APPARATUS.

of the machines for carrying out this operation.

The apparatus for carrying out the shredding consists of a series of reducing machines in line with each other, the general arrangement of which is shown in Fig. 3.

Figs. 4 and 5 show the details of each reducing machine—the former being a front view, and the latter a vertical section of the upper portion.

Each machine is provided with a pair of reducing rollers *C* and *D*, of which *C* is covered with a number of fine V-shaped grooves extending circumferentially, and cut about 20 to the inch. These grooves are $\frac{1}{10}$ of an inch wide and the same in depth. The bottom has not a sharp V, but has a surface of about $\frac{1}{6}$ of the depth. The roller *D* is smooth and of the same size as *C*, and the two are geared so as to run in contact at *E*. The bearings of the smooth roller are adjustable by means of an arrangement *L*. Both are provided with annular rebates *C* at their ends, to form bearings for the inner concave faces, h^3, of the lateral walls h^2, of the removable hopper *H*. Each end of the grooved roller carries a notched circular cam, C^1, the notches of the two cams being exactly opposite each other.

The driving shaft *G* carries a clutch pinion G^3 (Fig. 4), which is adapted to engage the gear wheel of the front roller; and the driving mechanism may be disengaged by a shifting lever which engages the clutch. Each driving shaft carries a pulley, G^1, which is belted to a line-shaft, and the machines are so arranged that the rollers all run at the same speed.

Each reducing machine is provided with a comb *a*, the teeth of which engage the grooves of the roller. Each comb is provided with a cleaner *b*, placed in an inclined position above the comb, and carried by lever arms provided with adjustable lugs which engage the notches of the cams of the grooved roller, and thus give the cleaner an intermittent motion towards the roller, whereby any accumulations of wheat on the scraper are pushed back to the machine. The hopper is provided with sectional lateral walls h^2, which have a sliding connection with the main frame of the hopper, and are adjustable in order to provide for the proper accommodation of the inside bearings of their concave edges to the bearings of the reducing rollers.

Inclined cut-off slides *f*, provided with rack and pinion devices f^1, are seated in ways in the hopper walls. The workman in charge may thus adjust the feed of grain or cut it off altogether. The hopper h^1, is supported upon adjustable set-screws *s*. Each reducing machine deposits through the action of its comb a layer of a thread-like product on a series of receiving troughs, which are carried by the endless belt *B*, which moves in a roller way in the frame *F* (Fig. 4). This belt is provided with lateral studs to keep the troughs in position. As each trough passes under the series of reducing machines the thick-

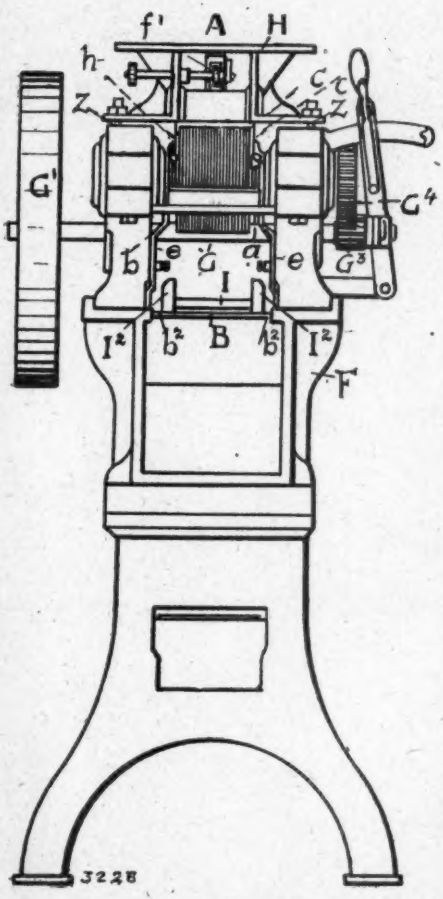


FIG. 4.—FRONT VIEW OF REDUCING MACHINE

ness of the product deposited gradually increases according to the number of machines, or the proportion of them in gear. In order to obtain a deposit of shredded material of suitable thickness, about thirty machines in the gang are required.

Fig. 7 shows one of these receiving troughs in position on the travelling belt. It consists of a trough about a yard long, having lateral walls, and open at the ends. At one end it is provided with catch lugs L^1, for the automatic operation of the cutter L (Fig. 3).

At one end of the series of machines is a trough-feeding table J (Figs. 3 and 6), having an adjustable guide to insure feeding the troughs in line with the belt B. The table is further fitted with a short feeding-belt K, driven at a somewhat higher speed than the main belt, so as to insure closing the troughs in abutted end-to-end position on the latter.

The cutter (Fig. 8), which divides the board of shredded wheat between the consecutive troughs, is secured upon the frame L beyond the last reducing head. Its frame L is provided with bearings for a parallel motion-hanger consisting of two parallel bars $l\ l$, pivoted at their upper ends at the points l^1, and connected at their lower ends by a link-bar l^2. Secured to the frame L is a knife frame N, in which is a knife m. The upper portion of this knife frame is connected to a retracting spring N^1, and at its lower corners are lugs n, arranged to be engaged by the projecting catches of the travelling receiving troughs. The bar l^3, which connects the ends of the parallel bars $l\ l$, is pivoted to the knife frame, and the stud l^6, which connects it with the hindermost bar, is extended on both sides so as to engage curved guide slots in either side of the

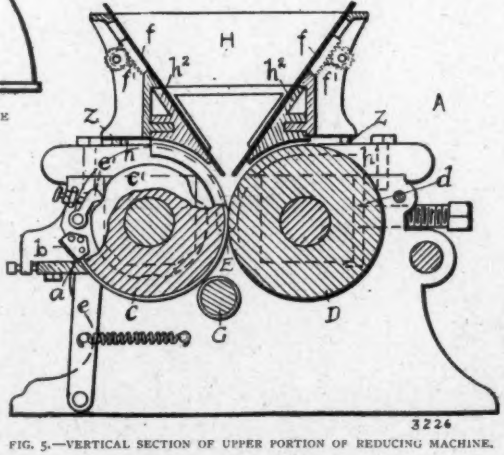


FIG. 5.—VERTICAL SECTION OF UPPER PORTION OF REDUCING MACHINE.

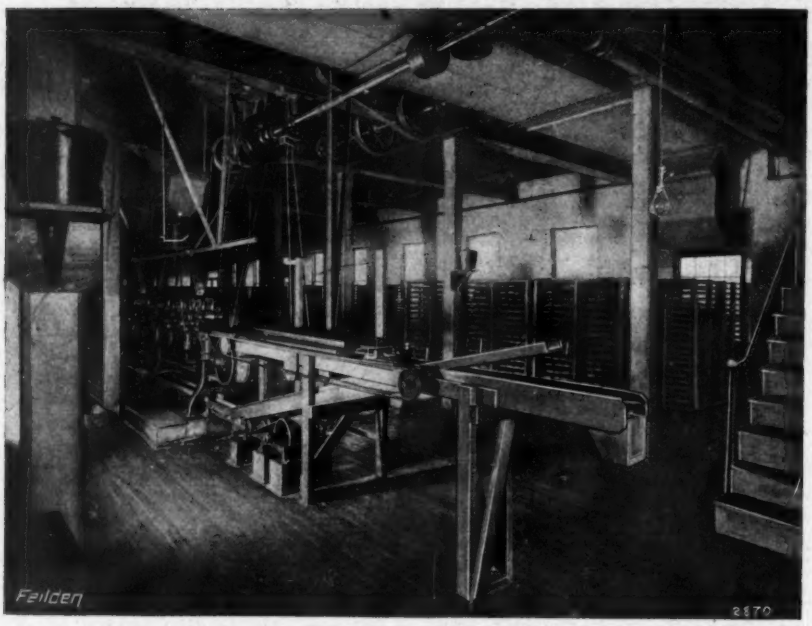


FIG. 6.—GENERAL VIEW OF MACHINES AND TROUGH FEEDING-TABLE.

frame L. Pivoted to the hanger at the point is a lever K^2, one arm of which engages a bearing, K^1, of the knife frame, while the other carries an anti-friction roller k^2, which engages the upper surface of a cam arm N^2. The latter is pivoted to the frame L, and carries a weight N^3 designed to give it an upward movement at the proper time. This arm is engaged and secured in a notch p^2 of the trip arm p, which is pivoted to the frame L. Attached to the hanger is a weight W, which serves to bring it back to its original position after action.

The machine works in the following manner. The catches L^1 of the travelling receiver come in contact with those of the knife frame, and carry it forward in the direction of the arrow to the position indicated in the figure by the dotted lines, and owing to the lever K^2 bearing on the arm N^2, and the engagement of the stud l^5 with the curved guide slots l^6, the knife is forced to the position indicated and makes its cut, without, however, changing its relative position with regard to the receiver troughs as they move forward in unison. When the roller K^{*2} comes in contact with the trip arm, the latter is forced from engagement with the cam arm N^2, which is therefore released, and the retracting spring is enabled to draw back the knife frame, while at the same time the weight W causes the hanger to return to its original position. The weight N^3 then raises the arm N^2 back into position to engage the trip arm again ready for the next cut. The hanger is prevented from returning too far by means of a stop P^2. As the series of troughs passes under the reducing machines layers of shredded wheat are deposited to the required thickness, and the long board of stuff is cut into sections at the junction of consecutive troughs. After passing the knife, each trough with its board of biscuit is received from the belt by workmen and arranged on a table, shown in Fig. 9, in a position

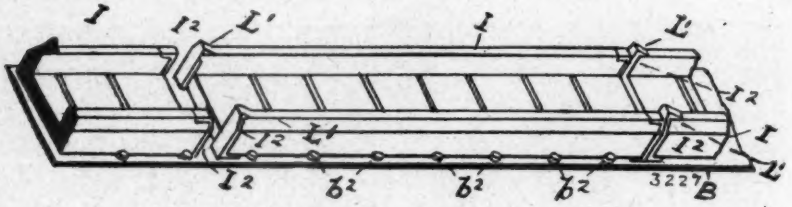


FIG. 7.—RECEIVING-TROUGH IN POSITION ON THE TRAVELLING BELT.

suitable for passing under a smaller cutter, worked by foot power. In this machine are arranged pairs of knives which have a vertical movement, and pass from above and below through the transverse slits in the bottom of the trough, and so divide the board of material into biscuits of the required size. The biscuits are then lifted by workmen by means of wooden or metal spades on to wire pans or trays, which are placed in racks and rolled to the baking ovens. Each wire tray holds about three dozen biscuits. The trays, with their load of biscuits, are transferred from the racks to the ovens, which are of the Ferris wheel type, and baked for about half-an-hour at a temperature of 560 degs. Fahr. After the baking the trays are again transferred to the racks and rolled to ovens at a lower degree of heat, where they undergo a further cooking for five or six hours.

The empty troughs are returned along the roller way *R* (Fig. 3), and pass up an inclined plane G^5 into position on the feed table *J*.

The effect of these bakings is to drive off a considerable proportion of the moisture, to render the bulk of the proteid matter insoluble in water, and to gelatinize the starch and convert a portion of it into soluble starch and dextrin.

After removing from the oven the wire pans are placed in racks and the biscuits allowed to cool. They are then placed on metal slides, which carry them to the packing table. The biscuits are then packed by hand in proper custom for the market.

The finished product is palatable and crisp, and in appearance somewhat resembles a small wickerwork oblong casket.

Among the advantages presented by this mode of preparing wheat for food, we may mention that it does away entirely with fermentation, and the consequent

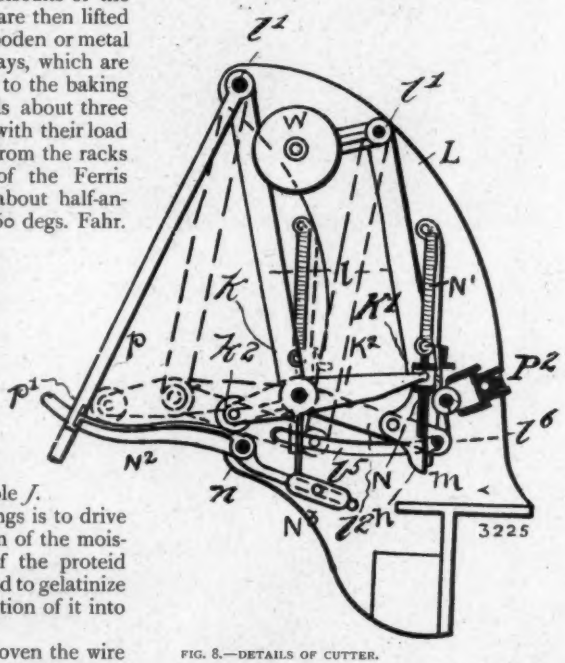


FIG. 8.—DETAILS OF CUTTER.

chemical changes in the constituents of the flour, and the losses owing to the decomposition of the starch and glucose. It has also the recommendation of absolute cleanliness, as the food is not touched by the human hand until the final packing, and the results are certain and uniform.

FIG. 9.—RECEIVING THE BISCUIT FROM THE MACHINES.

Furthermore, the biscuits, as far as proximate constituents are concerned, closely resemble the original wheat, as a comparison of the analyses given in Table II. with the following average results of analyses of shredded wheat made from time to time in the author's laboratory will make clear:—Moisture 8·5, ash 1·49, fat 2·4, carbohydrates 74·22, fibre 1·07, proteids 12·32. Cold water extract 9·15 per cent., containing sugar 0·68, soluble proteid 1·234, and dextrin and soluble starch, etc., 7·236. The soluble extract in the case of wheat varies considerably in different varieties, but is usually 5 to 7 per cent., and the soluble proteids 1 to 1·5 per cent. The cooking process does not, therefore, appear to have caused degradation of the starch to any very great extent.

The analyses below, collected by König (Table III.), will serve to illustrate the difference in composition between shredded wheat and ordinary bread :—

Mean of a Number of Analyses.	Moisture.	Proteids.	Fat.	Carbohydrates (starch, &c.)	Sugar.	Fibre.	Ash.
Fine Bread of white quality ...	38·51	6·82	0·77	49·97	2·37	0·38	1·18
Coarse Bread of coarse quality...	41·02	6·23	0·22	48·69	2·13	0·62	1·09

According to Moleschott, an average adult male doing the moderate amount of work of 300 ft.-tons per day would require, in order to keep in health, the following amounts of the various kinds of food :—Proteids 4·59 oz., fat 2·96 oz., carbohydrates 14·26 oz., salts 1·06, in all 22·87 oz. of water-free food.

If such a man were fed on 22·87 oz. of *dried* shredded wheat biscuit, dried fine and coarse bread respectively, according to the analyses quoted, he would obtain :—

	Proteid.	Fat.	Carbo-hydrates.	Salts.
From Shredded Wheat Biscuit	3·08	0·6	18·5	0·37
,, Fine Bread ...	2.53	0·28	19·46	0·43
,, Coarse Bread	2·41	0·08	19·7	0·42

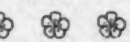
It is evident, therefore, that though shredded wheat falls short of the requirements of a perfect food, it is considerably in advance of ordinary bread. These calculations are, of course, made on the assumption that the whole of the proteid and carbohydrate matter would be absorbed in digestion—an assumption, perhaps, scarcely warrantable. There can, however, be no doubt that from a chemical point of view the preparation from the whole grain is of far greater dietetic value than white bread. Further, it is also a much more concentrated food, and it would be necessary to consume a much larger bulk of bread to get the 22·87 oz. of dry matter than of shredded wheat biscuit.

The biscuits are palatable and of pleasant flavour, but as to whether the latter is as likely to satisfy popular taste as that of bread we should not like to express an opinion. Shredded wheat has one very important advantage, that it keeps very well, and apparently neither absorbs nor loses water to any extent. It further lends itself in a remarkable degree to combination with other foods in cooking processes, and a number of excellent and attractive dishes may be readily prepared from it.

The comparative digestibility of shredded wheat, the various forms of bread, and other cereal preparations could only be decided satisfactorily by experiments on the human subject, and this we have not as yet had an opportunity of testing, though we hope to return to the subject at some future time. There appears, however, no reason to suspect that the biscuits would prove wanting in this respect.

Notes and Comments on Industrial Topics.

By JAMES VOSE.



In the article under the above heading which appeared in the December, 1900, number of this magazine, some remarks on the following subjects were reserved for a future issue, namely—

The technical or equivalent training of employers and employés,
The selection of intermediaries, and
The necessity for definite policies in the conduct of industrial concerns.

Touching on the first item, Lord Salisbury, some little time ago, in a speech in which he belittled the importance of the acquisition of foreign languages by English-speaking races, professed a cynical ignorance as to the meaning of the term "technical education," and of any benefit to this country likely to accrue from such. It is, however, some consolation that an increasing percentage of those engaged in industrial and commercial pursuits are disinclined to imitate his lordship's ostrich-like attitude on this subject, and appreciate the pertinacity with which Lord Rosebery urges all classes to rouse themselves from any species of fool's paradise, and face the fact that the best education obtainable is, in these days, none too good, if we wish to retain a position in the world's commerce consonant with our past record. For the purposes of this article we will consider technical training to mean the process passed through in the acquirement of the faculty of employing the best available means to the attainment of any given end. Let us consider the ends employers and employed need to endeavour to gain. The employer (considered individually as a direct employer, or as a unit in the directorate of a productive concern) is interested in so co-ordinating the various branches of the business and its management that a reasonable average return on a legitimate amount of capital is assured, and this, not by any process of killing the goose that lays the golden eggs, but by laying the foundation or continuing the superstructure of the business on such self-perpetuating lines as will tend to the indefinite prolongation of its healthy existence. To attain these ends a number of qualities need developing or acquiring. Chief among these may be mentioned, breadth of view, leadership, or the power of inspiring enthusiasm or efficiency in the performance of their duties on the part of subordinates, judicious self-effacement, and good sense of proportion.

For the position of a responsible official a comparative breadth of view is again desirable, coupled with the power of satisfactorily dealing with details. Other qualifications include proportionate leadership qualities, good judgment in miscellaneous matters, a keen sense of justice, and the instincts of a gentleman in the application of this sense to everyday industrial affairs.

The workman is all the better for the possession of, and the exercise of, alertness, craft-skill, enlightened subordination, and reliability. Applying equally to all ranks, may be added the qualification of physical fitness.

It would be presumption to attempt to lay down any very precise lines on which the first-mentioned class, on which, in our present social system, through family connections or inheritance, devolves the control of the destinies of already firmly established, or—in consequence of the possession of large available capital—quickly established businesses. However, observation and experience tend to give the impression that really serious study through the primary and secondary stages of education up to that of university grade, is, generally speaking, essential, and providing the classical element is not unduly magnified at the expense of the modern

side of the scheme of education, it does not appear that actual contact with the business eventually to be controlled need commence previous to the attainment of the student's majority, it being of course understood throughout that the training is only the foundation-laying of a business career. Mr. Hans Renold, the well-known power-transmission chainmaker, whose business is in itself an illustration of commercial and scientific success on the lines here suggested, recently wrote from Philadelphia, where he was then visiting several works, pointing out the much greater percentage of college and university trained men now commonly employed in American works, his point being that such training tended to give any concern taking advantage of it rapid and decisive initiative in the bringing out of new and successful lines. The imaginative faculty, often disparaged by the trainers of the youth of a not very remote period, must nowadays, under reasonable restraint, be admitted to be a desirable portion of the mental equipment of those occupying or aspiring to occupy positions of industrial leadership. But for the exercise of this faculty it is difficult to conceive how various modern successful businesses of a special character would have been evolved. But, many people may say, "Leaders of men are born such, and cannot be trained to order." This is true to a great extent, but just as the atmosphere in which the soldier lives, and the traditions with which he is imbued, almost invariably produce physical courage and endurance when such is called for, the incorporation of leadership as a subject for serious thought in any scheme of education or training can scarcely fail to bring out at the proper time such measure of the quality as may be inherent in the student.

Self-effacement may appear rather a curious virtue to include as a feature in an employer's equipment, but there is little doubt as to its value when judiciously applied. This application would take the form of cheerfully delegating as much freedom as possible to all subordinates as regards their methods of attaining their own special ends—*i.e.* the efficiency of their own department. This principle may be carried right down to the workman, who, *so long as the results of his labour are satisfactory*, should be interfered with as little as possible. Of course, autocratic government will often give very good results for a certain length of time, but a continuously successful business demands self-reliant men as its exponents, and such can only be produced by allowing reasonable scope to each individual. The sense of proportion mentioned in connection with the employer's desirable attributes is a very important item, and where well developed will obviate much needless worry and friction in a works' organisation. An incident stated as having occurred in an engineering works was somewhat as follows. Two labourers solemnly slung and lifted an object weighing about 56 lbs. into a truck with the aid of a modern electric crane, when the job might have been accomplished in very much less time by manual labour. The proprietor, asked by a visitor if such an occurrence did not considerably annoy him, replied, "It used to, but after a while I figured out that if all my men possessed and exercised as good judgment as myself and the staff, they would probably be my competitors instead of my workmen. This thought has often minimised worry, and is perhaps worth noting." Unless corrected by personal knowledge, preferably gained by actual well-planned travel and visitation of representative manufacturing concerns in various countries, there is generally a tendency to fancy one's own enterprise much more necessary to the world's industrial economy than is really the case; just as Tennyson's villagers "thought the rustic cackle of their bourg the murmur of the world." It appears to the writer the duty of every employer to obtain, in some way or other, the information necessary as a basis from which to build up this sense of proportion. Regarding the methods employed in the evolution of works' officials, until recently Germany and France have relied mainly on formally and definitely training engineers for these posts, but though satisfactory, especially in the case of Germany, under a protective fiscal system, in the

matter of quickly developing manufacturing industries of considerable importance, it has been felt that this method does not quite produce the class of ability desirable for *workshop* management. In this particular the English and Americans, and of late years the latter conspicuously, have excelled by virtue of an instinct for practically grasping the best methods of *applying* principles which the Continentals were perhaps more capable of analysing and theoretically demonstrating than they. Both English and Americans have trusted almost entirely to workshop-trained officials, but recently, in America, the college or technically trained official has been much in evidence, also with very good results.

This new class, however, takes as full advantage as possible of *workshop* training, either before or after the college course, and is becoming formidable enough to cause some alarm as to the future prospects of promotion open to those whose only available avenue is through the workshop.* This aspect of the matter has been considered of sufficient importance to be discussed editorially in a recent number of the *American Machinist*. So far as can be judged, workshop training, plus the theoretical evening training now available to willing candidates at many excellent technical schools, is likely to produce the greater number of successful managers, but the other classes ought not to be neglected by observant employers as a source of supply. One reason why a capable official produced under workshop conditions (and who is possessed of the gentlemanly instincts previously mentioned), is likely to be successful, is, that he is aware from actual experience, of the many drawbacks under which his subordinates often work, and can sympathise with them, and assist in the removal of, or the amelioration of these difficulties. Another reason is, that he is most likely to be familiar with the *exceptions* to sound general rules or conclusions. A former teacher of the writer, a gentleman whose name and character is held in respect by his pupils now occupying responsible positions all over the world, and who, while holding an important works' administrative post, was a self-sacrificing pioneer in the propagation of technical education (I refer to Councillor John Berry, J.P., of Bolton), in the course of his lectures, when incidentally including valued advice on workshop management, always laid special stress on the importance of observing the injunction, "be just and fear not." His personal example has probably borne fruit in many spheres of life and action. The constant exercise of the sense of justice tends to add increasing weight to the opinions and judgment of any works' official in the eyes of an employer worthy of good service. How many workshop disputes might be nipped in the bud if the disputants were compelled to state the case of their opponents as a preliminary to their own side of the matter being listened to? A non-partisan attitude on all subjects connected with his work is the only attitude of the true engineer. In order to produce workmen with the before-mentioned characteristics, much more thought will have to be bestowed on the subject than is at present the fashion. It is a mistake to suppose that modern methods dispense with skill. They only vary its distribution. As a contribution to this matter, the writer suggests that boys of good general education be taken at, say, 15 years of age, *at only half the now current rate of wages*, placed in the workshop under the surveillance of a competent instructor (as at Browne & Sharpe, The Baldwin Locomotive Works, Lud Loewe & Co., &c.), and compelled to attend a reasonable course of theoretical training, either inside or outside the works. From the age of 18 they should be paid strictly according to merit, so that, if capable, they would receive up to journeyman's wages. The half-wages part of the system would tend to weed out the non-stayers, and the merit system would enable parents and apprentices to be recouped for the initial sacrifice. The works would benefit by the regular accession of good new blood to the artisan ranks. To the objection that

* It is rather significant that the Massachusetts Institute of Technology have found such a demand for admission to their courses from English students that they have decided to arrange for entrance examinations being held in London.

such a course would only be training men for the benefit of other firms, it might be answered that any progressive firm will not shirk its share of pioneer work of any description, and that the services of good men of their own training are worth retaining at such a price as will deter them, except under special circumstances, from seeking other employment before their sponsors have received a proper return on their outlay of trouble and expense.

Touching on the selection of intermediaries, Professor Higgins, in an article which appeared in the July, 1901, number of *Cassier's Magazine*, deals with the topic in a very interesting manner, and a few excerpts from it will suffice to indicate our views and direct attention to the original article. "Thus far the writer has tried to show that the foreman should be a skilled mechanic, with a thorough technical education and the qualities of leadership. But this is only a part of what he should be. He might have all the above qualifications and not be a manly man, with the character of a gentleman. This demand upon the foreman is not for sentiment; it is for success in the shop. It is necessary for dividends and the supremacy of industry. Workmen cannot be forced to do right or to produce their best; they must be influenced to do so. Where can you find many men called upon to deal with so large a number of men of such varied and diversified temperaments? It requires a good man to influence men for good." Again, "It is easier to allow a workman to use a poorer method and to push him hard than it is to study to adopt a better method which will halve the cost of his product without overworking him." And, "The work of the future foreman will be to teach rather than to govern, and a good teacher must know both his subject and his pupils. Then he will succeed in proportion to his love for his subject and his pupils."

As to the necessity for definite policies in the conduct of industrial concerns, where such exist they are in the nature of labour-saving devices. Each departmental head is in a position to shape his course of action to the best advantage under the circumstances. If the policy is of a go-ahead or progressive nature, one calculated to induce all concerned to show themselves at their best, the success of the venture is practically assured. If the proprietors are inclined to work in a groove which, under the guise of "correct system," carefully limits all individual initiative and responsibility, one can understand and make the best of such conditions, and a moderate success is possible. If the policy is of the "keeping everybody in their places" and "attend to your work; all the necessary thinking is done in the office" order, the fact of the policy being well understood is at any rate of value to the staff and workpeople, as they are thereby enabled to choose the psychological moment for severing their connection with such a works, as few are likely to benefit by prolonged association with it.

Summing up these notes, the writer is of opinion that any genuinely successful business will be found on analysis to have had careful thought bestowed on the three points dealt with—training for all grades of duty, the selection of intermediaries, and the policy of the firm on all matters within its scope. He also takes the opportunity of acknowledging the Editor's courtesy in inviting expressions of opinion on such current topics from those "occupying a position intermediate between employers and employed," believing the ventilation of such topics desirable in the interests of all concerned in industrial and mercantile matters.

James Rae

The History of the Water-Tube Boiler Controversy.

BY AN EXPERT.

(Continued from page 244.)

❀ ❀ ❀

PART II.

THE German Naval authorities at first adopted the large-tube type of boiler, such as the Dürr, Belleville, and Niclausse; but they soon gave preference to boilers of the small-tube type. The *Internationale Revue ü d. ges Armeen und Flotten* writes as follows:—

"Although last year the large-tube systems, owing to their satisfactory qualities in other respects, were frequently used for new ships of the German Navy, they appear now to come into disuse. The reasons seem to be their great weight, the extravagant coal consumption, and the large amount of smoke developed as a result, the length of time it takes to clean them, and the absolute necessity of frequent cleaning in order to obviate disturbances in the operation, and finally the great sensitiveness of the types referred to even small quantities of salt in the feed-water. For instance, for one of the types mentioned above, it takes a whole week to take it apart, clean it, and mount it again. . . . A small quantity of salt in the water causes it to foam, and the strong water shock in the tubing, and especially the water entering the steam cylinders, endangers the whole engine installation to such an extent that it may disable it altogether. Hence a ship equipped with this type of boiler may be crippled even by small leakages in the condenser tubes."

In the German Navy, ships of from 13,000 to 25,000 h.p. water-tube boilers form only a part of their installation, the proportion to cylindrical boilers being from one-half to one-third.

The arguments against the suitability of the Belleville boiler are further strengthened by recent practice. Messrs. Armstrong, when left to their own designs, have always fitted in cylindrical boilers. In recent cruisers built by that firm, and with less displacement than the *Highflyer*, this firm managed to get into them 17,000 i.h.p., and make a speed of between 23 and 24 knots, with natural draught. The comparison is all the more striking against the Belleville type since the armament of Messrs. Armstrong's cruisers outclasses that of the cruisers of our own Navy.

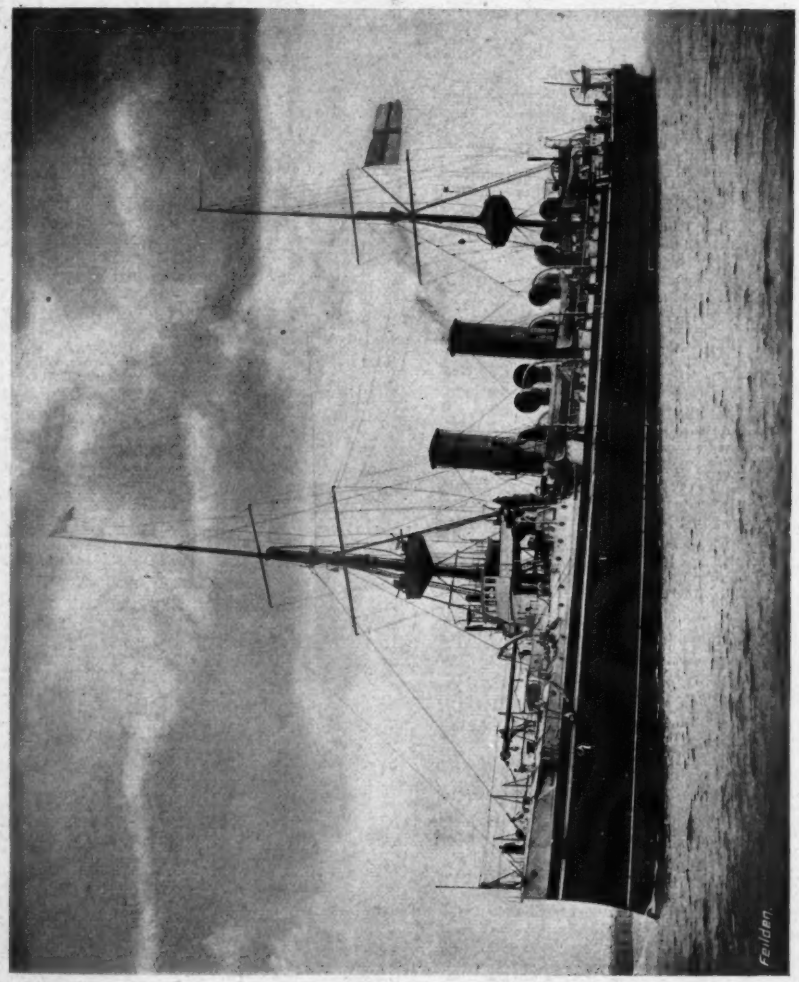
Now, further, it will not be forgotten that the Admiralty intended that the *Powerful* and *Terrible* should be the fastest cruisers afloat. It will be seen in what manner they succeeded. They were, anyway, to have three knots higher speed than the French vessel *D'Entrecasteaux*. Looking to the memorandum issued by the Admiralty, we find this entry: "This ship, the *Terrible*, also made a passage from Portsmouth to Malta, a distance of 2,200 miles, without stopping, in 1898, at an average speed of 17·7 knots." There are several short-distance trials where a higher speed than this was made after the ship had been got thoroughly ready for the purpose. There is a case where she made 20 knots for over 200 miles. There is a case of 20·65 knots for four hours, but her designed speed is 22 knots, and, like the *Oceanic* and *Deutschland*, she ought to make and keep at this speed right on for 3,000 miles, as they do. On long distances like that to Malta she can only make 17·7 knots. If the *Columbia* could be given a speed of 22·8 knots with cylindrical boilers, and with a displacement of 7,475 tons, surely the *Terrible* should make 22 knots with 14,200 tons!

Arguments, in fact, came from all quarters against the policy of the Admiralty, until there was nothing left the Government to do but to appoint a separate Commission to inquire into the state of the boilers of the fleet.

Not long after the Boiler Committee had been appointed, the Engineer-in-Chief of the Naval Bureau of Washington, Rear-Admiral Melville, issued his annual report. It came out before the interim report of

the Committee, and contained important references to the subject of water-tube boilers, and to the Belleville boiler in particular. When the extracts from that report were printed and published for the first time in this country by the *Pall Mall Gazette*, they caused considerable sensation, and leading articles appeared in many of the newspapers on the matter.

In this report Rear-Admiral Melville refers to the examination and close inspection which every new plan and design submitted to the American Naval Bureau has to undergo by the officers of the department. Improvements are continually being brought before them by inventors, and it requires care on the part of the engineer officers, in order that



H.M.S. "MINERVA."

[*Symonds, Portsmouth.*

Photo by] Faulden.

good inventions may be tried and bad ones rejected. Such an invention was the Belleville boiler, and it was brought before the department in the usual course.

The words used by Rear-Admiral Melville with reference to this are :—

"Some years ago the Department was urged, with no little pressure, to adopt the Belleville water-tube boiler as a standard for the new ships. This Bureau opposed the innovation wholly upon a close examination of the designs, criticising the very defective features which in later years have made conspicuous the comparative inefficiency of this type over the purely straight-tube type, for which I have given continuous and urgent preference. The Department is to be congratulated upon escape from this 'pressure,' and upon the the conservative approval it has given to the change in the boilers of naval ships. Instead of having been encumbered during the last war with ships powered with a type of boiler necessitating a specially trained force even for its safe operation, the most effective vessels had either retained the Scotch boiler or possessed the single straight-tube type, and remained free from any real danger of becoming *hors de combat* by reason of a lack of a completely experienced fire-room management, or the sudden failure of delicate or intricate special apparatus connected with the steam generators."

In our own country ample means have been afforded for coming to a decision on the question of the fitness of the Belleville boiler to supply steam to our ships. There was the accident on the *Terrible*, and the cost of repairs to her boilers since 1897 has been £10,456. There was the voyage of the *Europa* to Australia, when she took 49 days to make the passage, and consumed 6,000 tons of coal in doing so. There was the *Powerful's* crawl home from the Cape at nine knots, and the extensive trials of the *Highflyer* and *Minerva*, all pointing in the one direction. The *Diadem* also adds its sum of more to that which had too much. She was fitted with Belleville boilers, with economisers, and after being in commission less than two years,

"was laid up for an extensive overhauling and retubing of her boilers. A great number of pinholes were found in the economiser tubes, and £4,218 were expended in boiler repairs."

Almost immediately after the publication of this report in England, there came the Boiler Committee's report, which was a far more serious matter. First of all, the committee maintained that the water-tube boiler was a necessity to naval strategy. On this point they reported in a guarded way :—

"That the advantages of water-tube boilers for naval purposes are so great, chiefly from the military point of view, that, provided a satisfactory type of water-tube boiler be adopted, it would be more suitable for use in his Majesty's Navy than the cylindrical type of boiler."

Then came their pronouncement on the Belleville type :—

"(*a*) As regards ships which are to be ordered for the future—That Belleville boilers be not fitted in any case.

"(*b*) As regards ships recently ordered, for which the work done in the boilers is not too far advanced —That Belleville boilers be not fitted.

"(*c*) As regards ships under construction, for which the work is so far advanced that any alteration of type of boiler would delay the completion of the ships—That Belleville boilers be retained.

"(*d*) As regards completed ships—That Belleville boilers be retained as fitted."

The committee further recommended :—

"That the completion of the two sloops and the second-class cruiser fitting with Babcock and Wilcox boilers, and the sloop and first-class cruiser fitted with Niclausse boilers be expedited, in order that the value of these types of boilers for naval purposes may be ascertained. . . . Also that boilers of the Dürr and of a modified Yarrow type be made and tested at the earliest possible date under their supervision, with a view of aiding the selection of one or more types. . . . That two cruisers, not smaller than the *Medea* class . . . be placed at their disposal . . . and that Dürr and Yarrow boilers be fitted in them . . . so that the performance of the types of boilers named may be definitively ascertained under ordinary working conditions from extended sea-going trials. . . . All new vessels of large power should be provided with cylindrical boilers to do the auxiliary work. . . . A series of comparative trials for determining economy in coal and water consumption were arranged for his Majesty's ships *Minerva* and *Hyacinth*."

These trials were made to bring out points of comparison between the two systems of generating steam.

The *Hyacinth's* length is 350 ft., breadth of beam 54 ft., and mean draught 20 ft. 6 ins., the displacement being 5,600 tons.

The *Minerva* is of the same dimensions, with the exception of her breadth, which is 6 ins. less than that of the *Hyacinth*. Under the same power they made the same speed. The engines are different; those of the *Hyacinth* are of a more modern design. The *Minerva's* engines have a longer stroke, make fewer revolutions per minute, but have about the same

piston speed. Both have twin screws; those of the *Hyacinth* make 180 revolutions per minute, while those of the *Minerva* make 140.

Coal consumption trials were made first, and these under different conditions, first at the low power of 2,000 i.h.p., then at 5,000 i.h.p., and lastly at 8,000 i.h.p. It was considered undesirable to attempt to develop a higher power than this with the machinery of the *Minerva*, but the *Hyacinth* was tried at the very highest power, and developed over 10,000 h.p. Now, the following speeds were obtained at the various powers developed :—

Horse-power.	*Minerva.* Speed.	*Hyacinth.* Speed.
2,000 ...	12 knots ...	12 knots.
5,000 ...	16 ,, ...	16 ,,
8,000 ...	18 ,, ...	18½ ,,
10,000 ...	— ...	20 ,,

So that, from the table, one would infer that the *Hyacinth* could make a clear two knots more an hour than the *Minerva*, and in a race could simply steam easily away from the older ship.

The coal consumption results showed a slight advantage in favour of the Belleville ship, but it was discovered before the trials were over that the Admiralty had never entertained Mr. Manuel's suggestion to try retarders. When this was known the committee ordered that the tubes should be fitted with them, and a special trial was made to ascertain if any advantage followed their adoption. The result was as follows, in the words of the report :—

"*Minerva's* trials made with and without retarders. The special trial at half-power, 4,771 h.p., made with half number of boilers, showed a gain in evaporation of 11·05 per cent., due to the use of retarders."

The result in coal consumption is given in the following words:—

"Burned with retarders 17·9 per cent. less (coal) than without."

When then the coal consumption, as found from the trials for the *Minerva*, is reduced, to allow for retarders, the following is the result :—

Horse-power	2,000	5,000	8,000
Lbs. of coal per i.h.p. :			
Belleville boilers ...	2·03	1·84	1·84
Cylindrical boilers ...	1·768	1·43	1·98

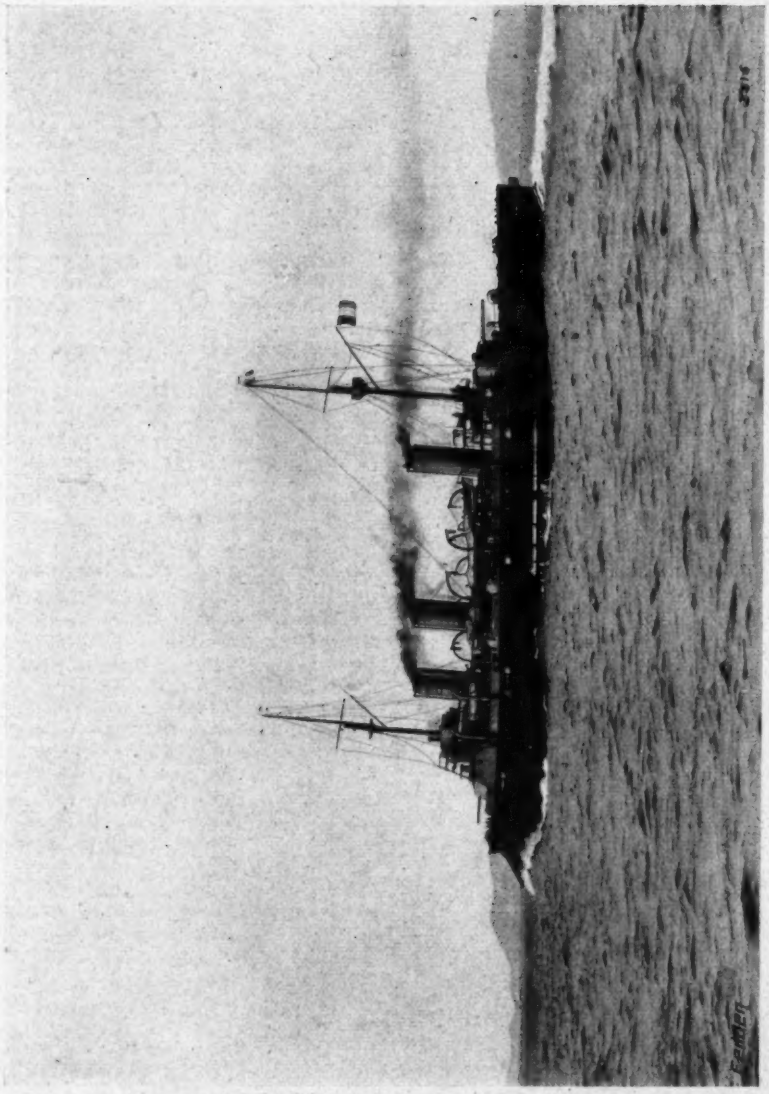
It must be said that the consumption results for the *Hyacinth* are extremely good, but it must not be taken as an average. The consumption of coal of the *Sharpshooter's* boilers was seen to be 2¼ lbs. per horse-power.

But the great difficulty experienced during the trials of the *Hyacinth* was the leakage of water from her joints. During the coal consumption trials at 2,000, 5,000, and 8,000 h.p. the leakage of water from the cylindrical boilers was 2·14, 2·76, and 3.73 tons per 1,000 h.p. per day; while the leakage from the Belleville boilers was 5·5, 2·76, and 5·57 tons respectively per 1,000 h.p. per day. It will be observed that the leakage of the cylindrical type increases, as is to be expected, with the rate at which they are worked, while no rule applies to the Belleville leakage. Apparently, it depended on the state of the joints when the trial began; but it is obviously much higher with the Belleville type than with the cylindrical.

The trials finished with a long-endurance trial, in which the ships were to steam at about 17 knots, side by side, until the equal quantities of coal of the same quality taken on board each vessel was exhausted. The ships, with members of the Committee on each, were to steam from Devonport to Gibraltar, and cruise about outside the Rock, and the time of endurance was to be recorded. Special reserve tanks of fresh water had been fitted on board each ship. The total reserve-tank storage on the *Hyacinth* was 140 tons, while that on the *Minerva* was 170 tons.

The cruisers sailed at 3 p.m. from Devonport on July 6th, 1901. On the 9th the reserve water on the *Hyacinth* had been reduced to 35 tons, and two evaporators, working with exhaust steam, were started, to make up feed, at 5.30 a.m. on the 9th. On the 10th the remaining two evaporators had to be started at 1.15 a.m. On July 11th, after 103¼ hours' steaming, the trial of the *Hyacinth* was abandoned, and she put into Gibraltar at slow speed.

The *Minerva* kept up steaming at the same rate of speed, and her engines



THE FRENCH CRUISER "D'ENTRECASTEAUX." [*Symonds, Portsmouth.*

Photo by]

developed 7,000 h.p. till 11 p.m. on the 12th, at which time she had still 39 tons of coal remaining, besides the reserve of 82 tons; and there was still the water reserve of 20 tons in the tanks. She had steamed at an average of 7,007 h.p., and made 17·96 knots. The *Hyacinth* had to abandon her trial after she had only made 1,810 miles, and she developed an average of 7,047 h.p., and made 17·6 knots speed. The cruising radius, therefore, of the water-tube boiler ship was to that of the cylindrical as 1,810 is to 2,640, or as 9 is to 13.

A curious conclusion is come to in the report issued by the Admiralty, and signed by Vice-Admiral Domville. The statement is that the radius of action of the *Hyacinth*, based on a calculation of her coal consumption, is 2,930 miles. But surely it is no use basing the radius of action on the coal consumption if a ship uniformly breaks down long before the coal is exhausted. One authority has put this point in a manner which can be understood. He says:

"The radius of action of a ship fitted with Belleville boilers does not depend on the coal she carries, but on the leakage of her joints. The longer she steams the greater does the leakage become. The leakage is an increasing quantity, and the voyage terminates when the leakage becomes equal to the capacity of the evaporators. The condition of things on board a Belleville ship is exactly similar to that on board an old hulk—liable to spring leaks. As the voyage of the old hulk proceeds the leaks increase in number and extent. The hulk goes on so long as the pump capacity is greater than the leakage, but there comes a time when the leakage equals the capacity of pumps, and after that she settles down and gradually disappears. After the leakage becomes greater than the capacity of the fresh water making evaporators the trial is over. The distance she has steamed up to that time is her radius of action."

The voyage home revealed the same condition of things on board the *Hyacinth* which existed on the way out, even though she had been thoroughly overhauled and examined while she lay at Gibraltar. The report of this examination states:—

"The loss of water in the *Hyacinth* was at first attributed to leaky suction pipes,"

but this was found not to be the case. The report goes on:—

"The leaky joints in the *Hyacinth's* boilers were re-made by the ship's staff, and on Tuesday, the 16th, the ship was taken out for a run at about 7,000 h.p., to test the amount of feed-water being lost; this was found to be at the rate of 55 tons a day."

Before the *Hyacinth* started for home her double bottoms were filled with fresh water, as a very necessary precaution, as well as her reserve tanks, which had a capacity of 140 tons. Both ships were allowed to use 40 tons, but any quantity above this was to be supplied by the evaporators, and anything more than 40 tons was to be taken when the evaporators could not supply enough to make up the deficiency. The whole 40 tons besides what the evaporators had made were used up after the *Hyacinth* had steamed homeward bound for two days 12¾ hours, then from that time she steamed 16½ hours and reached St. Catherine's Point, where the trial ended. During these 16½ hours the evaporators were at work to their full capacity, and all the water they made was applied to make up the leakage, and 58 tons of reserve besides. By the time the trial ended the leakage was increasing at a rapid rate, and only a few hours' further steaming would have brought the trial to an end by necessity. The *Minerva* was by that time in port some two hours ahead, and in good condition.

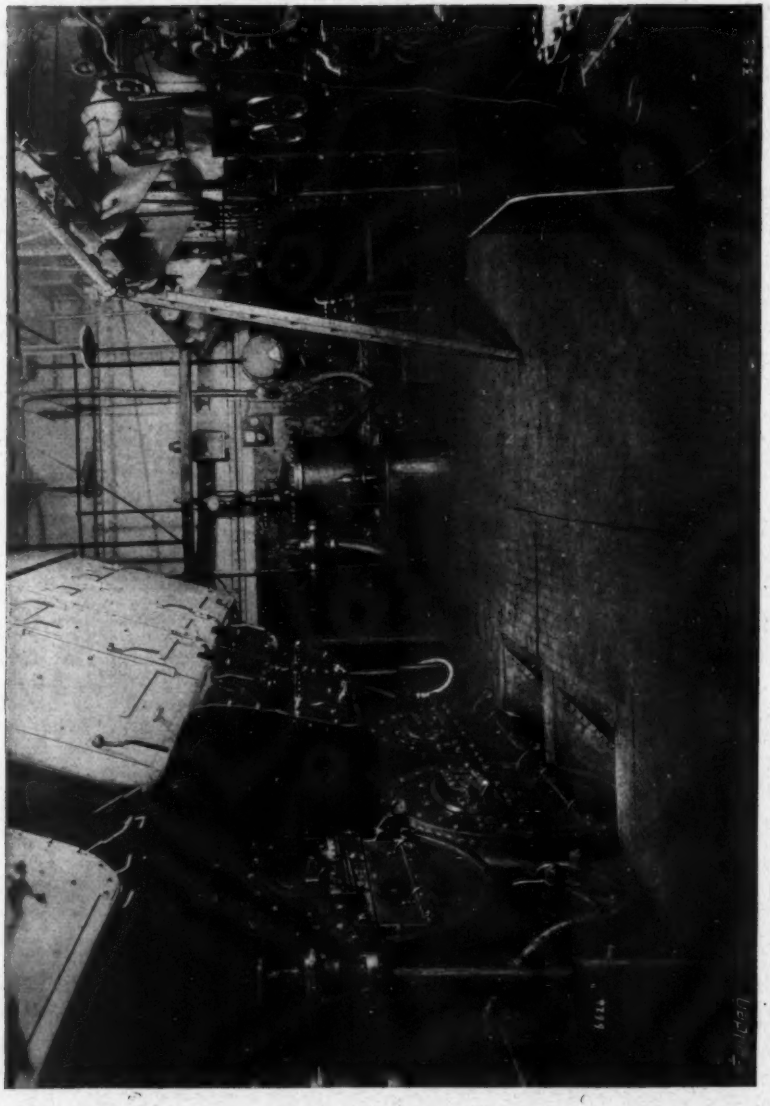
These three cruisers, the *Highflyer*, the *Hyacinth*, and the *Hermes*, were believed to have a knot more speed than their sister-ships of the *Minerva* class. So on the way home the Boiler Committee started them fair twice and let them go for all they were worth. Vice-Admiral Domville himself reported in very simple words what took place when this was done:—

"On emerging from the fog the ships were nearly level. . . . Throughout the day the *Minerva* was stated to have gained one-third of a knot an hour faster than the *Hyacinth*."

Then, after the second fair start, he reports:—

"On the 19th they were again level. . . . During the day the *Minerva* gradually drew ahead, and was stated to be going quarter of a knot faster than the *Hyacinth*."

One of the points on which the Admiralty laid great stress was the saving of weight and space in ships fitted with Belleville



THE STOKEHOLD, H.M.S. "RENOWN."

Photo by [*Symonds, Portsmouth.*

boilers, which saving of weight allowed of higher speed being made. But this has very little justification in fact. Take examples, in order that comparisons may be made. The engines of H.M.S. *Andromeda* and the Chinese cruiser *Hai-Chi* develop about the same power. The *Andromeda* is fitted with thirty Belleville boilers, and her engines develop at full power 16,500 h.p. The *Hai-Chi* is fitted with eight cylindrical boilers, four of which are double-ended and four single-ended, and her engines develop at full power 17,000 h.p. The weight of the Belleville boilers and the auxiliaries in the stokehold is 770 tons, while the weight of boilers and auxiliaries in the stokehold of the *Hai-Chi* is 741 tons; and so the boilers of the *Hai-Chi* supply steam for 500 h.p. more than those of the *Andromeda* for 30 tons less weight.

Then as to the question of space, the weights might be in favour of the cylindrical boiler, and yet the space taken up by them might be against their being fitted in the navy ships. It appears from the investigations of Mr. Marshall, of Hawthorne, Leslie & Co., that no advantage can be claimed for the water-tube boiler in point of floor space. The conclusion he has come to is as follows:—

"On looking at the floor space occupied by the three types of boilers, it will be seen the horse-power developed per square foot under natural draught is approximately the same. In other words, for continuous steaming, practically the same power may be obtained from the same size of boiler room whichever of the three systems is adopted."

The number of indicated horse-power per square foot of boiler-room area is, for the Belleville type 3·35, for the Yarrow 3·28, and for the cylindrical 3·46.

It has been maintained by superintendent engineers of the large lines of steamers that the comparisons made are always with cylindrical boilers of an old type. If the Admiralty wish to be quite fair, these gentlemen say, they will compare the weights and performances of water-tube boilers with the weights and performances of modernised cylindrical boilers fitted with forced draught arrangements. The weights of boilers to produce a given power are certainly greatly reduced when fitted with forced draught and all modern improvements.

In order that such a comparison may be made, we cannot do better than quote from an article in the *Pall Mall Gazette*. The ships taken are the *Andromeda*, 16,500 i.h.p.; the *Hai-Chi*, 17,000; the *Hermes*, 10,000; and *Æolus*, 9,000. Says the *Pall Mall Gazette*:—

"The first, the *Andromeda*, could be fitted with eight double-ended boilers, 18 ft. long 13 ft. diameter, and with a working pressure of 185 lbs. The weight of these, with forced draught arrangements with uptake funnels, etc., would be 648 tons, and they could supply steam to engines indicating 18,000 h.p. The other pair of ships, the *Hermes* and the *Æolus*, would be fitted with similar boilers. In these four double-ended boilers would be required of the same dimensions; the weight of the boilers would be 324 tons, and they could supply steam to engines of 9,000 i.h.p.

"In order that the advantages and disadvantages may be seen, they are arranged in tabular form.

	Andromeda.	*Hai-Chi.*	*Either Ship.*	*Hermes.*	*Æolus.*	*Either Ship.*
	Belleville	Cylindrical	With Howden's forced draught	Belleville	Cylindrical	With Howden's forced draught
Horse-power	16,500	17,000	18,000	10,000	9,000	9,000
Weights of boilers ...	770 tons	741 tons	648 tons	472 tons	428 tons	324 tons

"While the Belleville would burn on an average 3 lbs. of coal per unit, the cylindrical would use 1·5 lbs."

An important addition has been made to the history of this question during the last month by the publication of the Boiler Committee's report on the cruisers' race to and from Gibraltar. The report further deals with the results obtained from a run in the *Saxonia*, a Cunard liner, between Liverpool and Queenstown. These results of the trial on the *Saxonia* allowed a comparison to be made between the working of a ship of the mercantile marine and those in the navy.

The *Saxonia* is fitted with quadruple

expansion engines, with four cylinders and four cranks. They indicate between 9,000 and 10,000 h.p., and the steam is supplied by cylindrical boilers fitted with Howden's system of forced draught, the steam being supplied at a pressure of 210 lbs. In this system the air to be used in the furnace for the combustion of the coal is first heated by the waste gases. The air is thus put in a better condition to combine with the coal, the waste gases are reduced in temperature before they escape, and much heat is saved which in ordinary cases would get away unutilised.

There are two items which come out very prominently in these results which deserve to be permanently recorded. They are, first, the comparative temperatures of the waste gases in the funnel; and, secondly, the advantages of the use of retarders in the tubes of cylindrical boilers. In order that this comparison may appear quite fair, we take the results when the ships were working under nearly the same conditions. When the *Minerva's* engines developed 8,132 h.p. and 30·3 lbs. of coal were burned per square foot of grate area, the temperature of the funnel gases was 804 degs.; and when the *Hyacinth* developed 10,180 h.p. and made 20 knots an hour the temperature of her waste gases in the funnel was 780 degs. The temperature of the waste gases of the *Saxonia* was 396 degs., and the Committee point out that in this case the saving by heating the air is 4 per cent of the total heat of the fuel.

In the tubes of the *Saxonia's* boilers retarders were placed which caused the hot gases to move through them in a spiral direction and give up more heat to the water. These retarders promoted transmission of heat through the tubes. But retarders never have been placed in the tubes of the boilers of the *Minerva*, nor had that other economical process of heating the air before combustion been introduced. Hence the high temperature of 804 degs. of the escaping gases in the *Minerva's* funnels. Seeing this extravagant waste of fuel, the Committee ordered retarders to be placed in the tubes of the *Minerva's* boilers, with the result that the temperature of the escaping gases was reduced to 699 degs., showing a saving of 105 degs. of temperature, which, measured in coal consumption, showed a saving of 17 per cent. Had the air of combustion been heated in the *Minerva* as it was in the *Saxonia* a still greater saving of coal would have been effected.

There is one further point to be noted in the report just issued by the committee. It is as to the radius of action of warships fitted with Belleville boilers. In the report issued by the Admiralty almost immediately after the cruisers' race had taken place, Admiral Domville said that the *Hyacinth* had a radius of action which was measured by the quantity of coal which she carried in her bunkers. We joined issue with Admiral Domville on this, and said that the radius of action of a warship fitted with Belleville boilers did not depend on the coal which she carried but on the leakage of the joints of her boilers. And the committee, including Admiral Domville, agree with us, and say it is the leakage, and not the quantity of coal carried in her bunkers, which determines the radius of action. Their words are—

> "The story of the trial has already been told in an interim report issued some months ago by Admiral Domville, the president of the committee, and the exhaustive inquiry into the data collected shows that, so far as the *Hyacinth* is concerned, her radius of action was really determined by the amount of water lost and her inability to continue without using sea water to make up this loss for feeding the boilers."

Careful examination of the *Hyacinth's* boilers at Portsmouth showed that no extraordinary injury had been done to the boilers to account for the leakage. It was, indeed, due to inherent faults of the design, which is shown by the figures representing the loss by leakage. On the voyage to Gibraltar it was found that for the 7,000 h.p. developed the *Hyacinth's* boilers and engines were losing a total of 63 tons per day; while the *Minerva*, with cylindrical boilers, was only losing 24 tons in the same period. The same difficulties were experienced with the ship on the run home. The loss of water on the *Hyacinth* in this case, for 8,000 h.p., being even greater than on the outward run, the

leakage was 133 tons for twenty-four hours.

The Committee began its labours by issuing a report in favour of water-tube boilers in the abstract, and in the conclusions of this report they still adhere to their original opinions. But curious methods are adopted in support of their case. For example, they still maintain that the *Hyacinth's* boilers have an advantage in weight when compared with cylindrical boilers. The cylindrical boilers taken to compare them with are those of the *Minerva*, which are quite out of date. Two members of the Committee would not consider for a moment fitting boilers of the *Minerva* type into the mercantile ships for the machinery for which they are responsible. The Committee say the *Hyacinth's* boilers weigh 453 tons against 558 tons of those of the *Minerva*. Yet they admit that the *Hyacinth* consumed 100 tons more coal than the *Minerva* in her run home from the Rock. If a ship fitted with Belleville boilers consumes 100 tons of coal more than one fitted with cylindrical boilers in a distance of 1,200 miles, and the Belleville boilers weigh 90 tons less, the advantage is not very apparent. On the voyage outward the distance steamed was 1,810 miles, and then there was a hopeless breakdown from leakage of the Belleville ship when the engines were developing only 7,000 h.p. The advantage of weight on a voyage to New York, a distance of 3,000 miles, would be greatly against the Belleville ship, as she would consume 100 tons more coal per 1,000 miles. But the leakage would stop her long before she reached New York. Indeed, the evidence given in the report bears out the previous conclusion in the matter:—That a week's steaming at full power would reduce the whole of the 60 ships fitted with Belleville boilers to derelicts.

We come now to the conclusion of the whole matter, which has been stated over and over again by the greatest of the authorities. We give their names. Mr. John Penn, Sir E. Harland, Mr. Wm. Allan, Mr. B. Forwood, and others have insisted on long-distance full-power trials for warships of the British Navy.

We ask, then, for each of the types of new boilers to be tried by sending the ships in which they are fitted across the Atlantic and back at full speed as soon as they are fitted. Those types of boilers which fail under such a test should be abandoned. The British people cannot afford to have ships which form their first line of defence made experiments of, and their dockyards turned into laboratories. The people are paying for real fighting ships and real dockyards, and it is their intention to have what they are paying for.

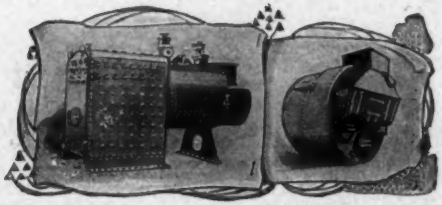
The trouble at the Admiralty, which has resulted in such a condition of things, is perhaps due to bad management. Sir Edward Reid, while he was Chief Constructor, had serious complaints to make. It is an old sore. Long ago, while Earl Northbrook was First Lord of the Admiralty, a Departmental Committee was appointed, with Lord Brassey as its chairman, to examine methods for the better organisation of the Admiralty. That Committee recommended the devolution of powers to men who would take charge of and be responsible for departments under Sir William White. Something towards the preparation of such men had been made by the institution of the Naval College at Greenwich. It was intended that the Naval College should assist in providing a better qualified *personnel*. There is the same trouble in the Naval Bureau of Washington. There has been an attempt to centralise the management so that it will be under a man who will pose as an expert in everything. Against this Rear-Admiral Melville enters a strong protest. At present there is the Construction Department and the Steam Engineering Department. Rear-Admiral Melville, who is chief of the Engineering Department, sees quite clearly the manner in which pressure might be brought to bear on him as chief of his department by one who thus posed as an expert, and that he (Rear-Admiral Melville) might be overruled in engineering work, as was our own engineer-in-chief when he protested against fitting in water-tube boilers indiscriminately and without previous experiment. The whole success of great

shipbuilding yards, Admiral Melville says, depends on the bureau system. His words are :—

"In every large shipbuilding establishment the bureau system actually prevails, to a more complete separation of the special branches of this work than has ever been practised in the Navy. Nominally, there is a head of each concern; but no pretence is ever made by that head of possessing expert knowledge regarding all the branches of the establishment. Frequently this head is not a technical expert at all, but simply a good 'general manager,' even though he has another 'general manager' under him, and also an expert chief for each separate division. Every tendency is to increase specialisation in work owing to the ascertained value of a system whereby leading talent in each department may devote itself to the advancement of its own particular branch, and not to be diverted therefrom through a maze of miscellaneous and unrelated work. Your impression that the work of the three bureaus is an integral work is certainly not gained by a close examination of the character of their separate specialities. . . . . If a naval constructor should be found to pose as an expert engineer, it would necessarily mean one of two things—either that he had neglected to a most serious extent the pursuit of his own profession, or that his own profession possessed but little requiring absorbing study and great experience, and therefore gave him the needed time for the study and pursuit of engineering. . . . The surest road to increased success in naval administration must be along the lines so clearly indicated in civil life—those of specialisation and continued subdivision."

But since Lord Selborne became First Lord, it must be confessed there appears to be a marked improvement. As soon as the Boilers Committee let their wishes be known, the First Lord eagerly set about making the necessary reforms and carrying out the instructions and suggestions laid down. The same thing has been done with regard to the question of destroyers. No sooner was it really brought home to the Admiralty that they had been simply building smooth-water boats fitted better for regattas than for sea actions, than Lord Selborne again promised that they would forthwith be strengthened. A committee of outside experts has been appointed to examine fully into that matter and report.

Geo. Halliday



Machinery in the Tea Industry.

By H. J. KERSTING GREEN.

Two teaspoonfuls to the cup; a well heated earthenware pot; boiling—boiling water, and don't let it stand more than three minutes. Beyond this, the average tea consumer finds little or no interest. The preparation of those black curly leaves is a huge industry in the Far East; and one in which vast capital is invested. The discovery of the tea plant in North Eastern India, about the year 1826, was followed by the importation of Chinese tea makers, to instruct us in the process of manufacture; and it rather looks as though "John" enjoyed a joke at our expense, because there appears to have been a glorious state of uncertainty as to whether the day's work would produce the black or the green variety. An article creates a market; but when a market demands a certain article, it has to be supplied, and the all-pervading power of the London market demanded black tea from India. It was not, however, until well into the seventies that machinery began to play any sort of part in its manufacture; when it was predicted that, before the end of the eighties, the clock and the thermometer would govern the whole system: this, as will be seen, has not yet come to pass; and it is more than doubtful if it ever will—all the strides in that direction duly considered.

The tea factory is usually a building constructed with a pitch or curved corrugated iron roof, of one, two or three stories. Fig. 1 is an illustration of a two-storied building—150 ft. long by 40 ft. wide by 22 ft. to the eaves, with two verandahs 20 ft. wide on either side, sufficient for the requirements of a factory, with an out-turn of 240,000 lbs. The amalgamation of smaller concerns and the centralisation of manufacture have, during recent years, created the necessity for very much more commodious structures.

Fig. 2 represents a building of three stories, covering a base area of 25,470 sq. ft., to be found on an estate producing 700,000 to 800,000 lbs. annually.

In arranging a factory there has been considerable scope for ideas regarding facilities and economy, the point not to be lost sight of being that the article should progress from one end of the house to the other, and traversing backwards and forwards avoided as much as possible.

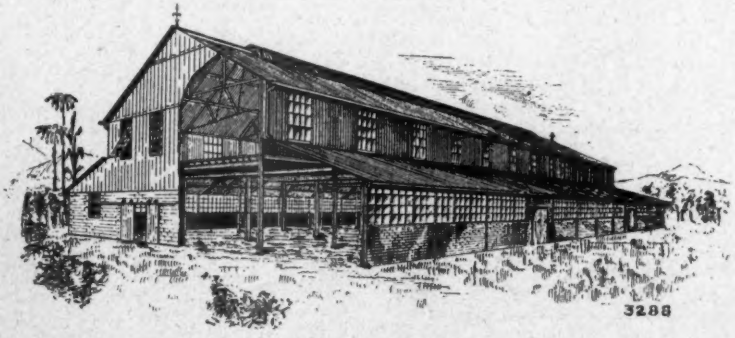


FIG. 1.—TWO-STORIED TEA FACTORY.

Thus, from the weighing in to the withering chambers—as will be seen, these may be part of the main building, or separate—from withering to rolling, from rolling to fermenting, colouring or oxydising, whichever term may be considered the correct one, a return to the rolling tables and to the fermenting again, thence to the firing machines, the drying or firing should be always in two stages. Sorting, final firing, and packing being the following day's work, is mostly, and should always be, kept as distinct a department as possible. Likewise the rolling machines should be so placed that they may be affected as little as possible by the heat from the boiler and dryers, the object being to keep the leaf at the lowest obtainable temperature during this process. Figs. Nos. 3, 4, 5, 6, are a selection of designs for the arrangement of factories of varying capacities, by Mr. William Jackson, and will serve to convey a correct and clear idea of the internal organisation of a tea house.

Fig. 3 shows a factory for small estate, arranged with verandahs at one end only, so as to provide ample room for machinery. The withering loft is above the machine room, and is fitted with racks running longitudinally.

Fig. 4 is a suitable iron house for a medium-sized estate, without verandahs, with small tramway running right through to facilitate the moving of the material. The dryers are automatic and are fired from one pit. The withering loft is equipped with air propellers to assist the ventilation and withering.

Fig. 5 represents a design for a medium-sized factory, with verandah all round, and two withering lofts above the machine-room. These are made clear by three cross-sectional views at different parts of the structure. The ground-floor is intersected by small light narrow-gauge rails.

The rolling machinery is arranged in two groups, for first and second rolling, with rolled leaf separators arranged between.

The dryers and steam boiler are all fired from one position so as to keep the fuel together.

Fig 6. This design is suitable for an estate of considerable size, and is capable of a large output, the withering accommodation being composed of two floors, extending the whole length of the building, fitted with withering racks and air propellers.

Rails are placed to serve the various departments in a ready manner, and the fermenting space arranged at each side of the rollers so as to obtain cool fermentation, by avoiding the morning or afternoon sun, as required.

The steam boilers and drying machinery are all fired from one position, and are served by rails. The smoke from boilers and dryers is carried off by one main chimney, with the exception of that of the dryer for final firing.

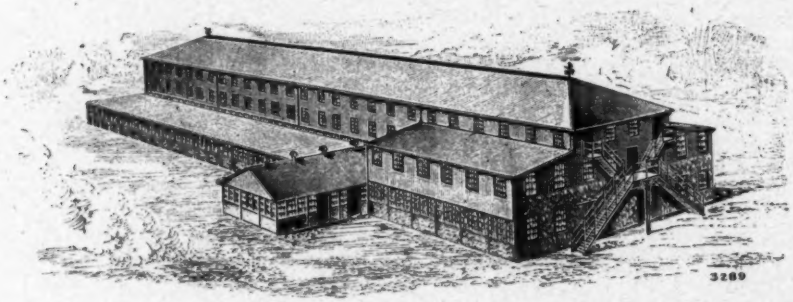
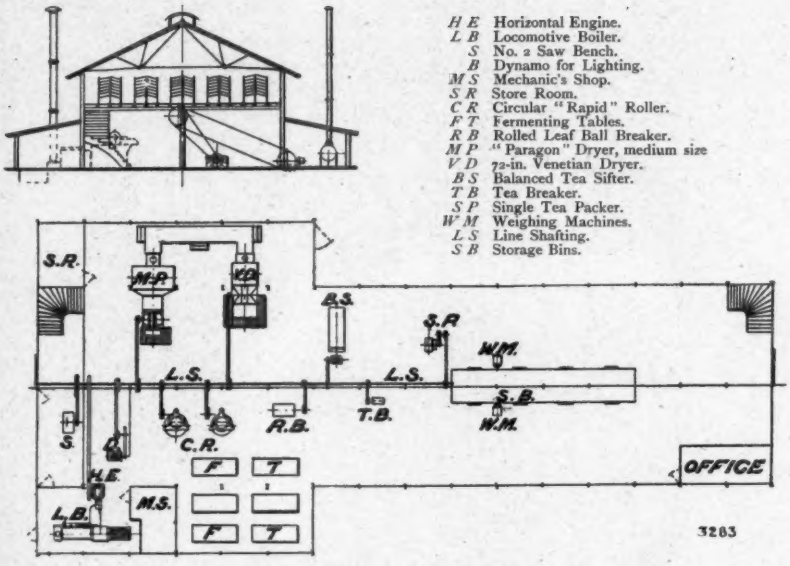
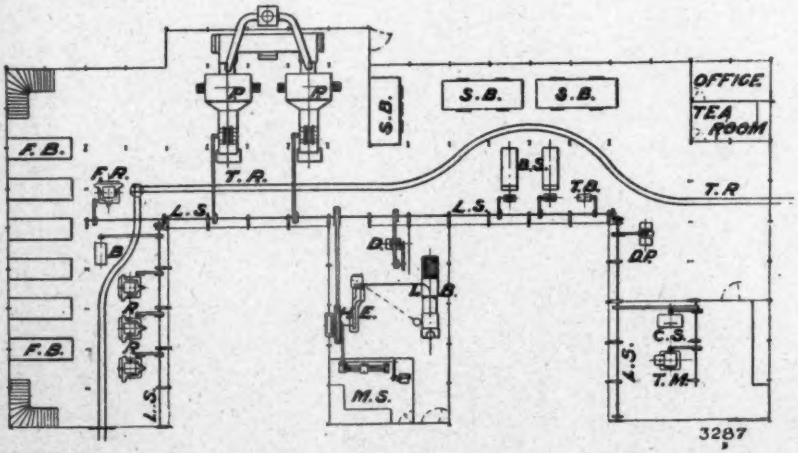


FIG. 2.—TEA FACTORY OF THREE STORIES.



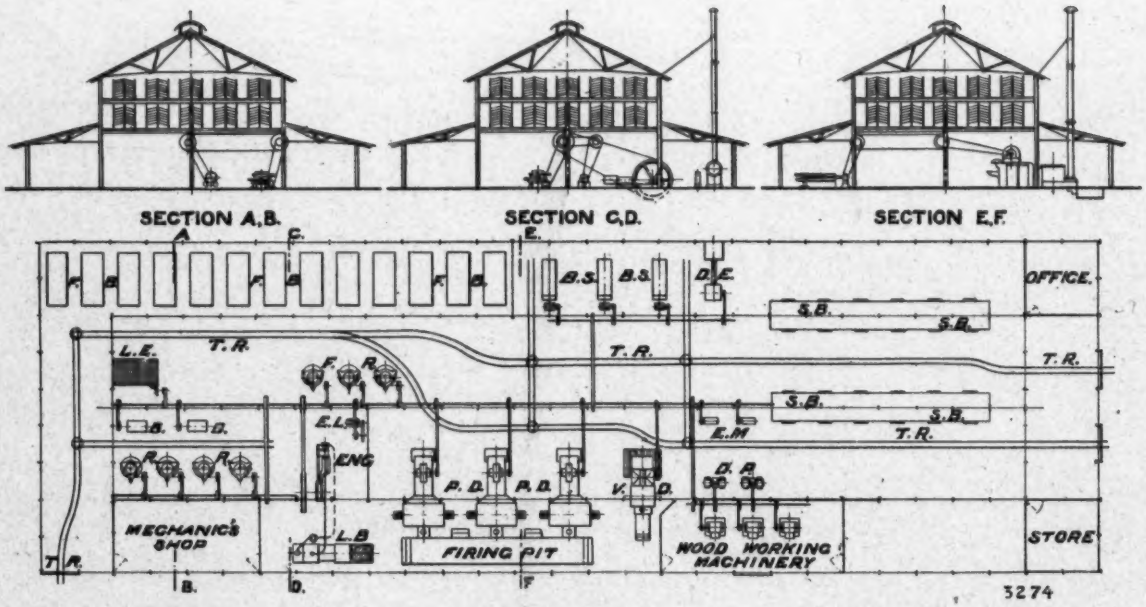
H E Horizontal Engine.
L B Locomotive Boiler.
S No. 2 Saw Bench.
B Dynamo for Lighting.
M S Mechanic's Shop.
S R Store Room.
C R Circular "Rapid" Roller.
F T Fermenting Tables.
R B Rolled Leaf Ball Breaker.
M P "Paragon" Dryer, medium size
V D 72-in. Venetian Dryer.
B S Balanced Tea Sifter.
T B Tea Breaker.
S P Single Tea Packer.
W M Weighing Machines.
L S Line Shafting.
S B Storage Bins.

FIG. 3.—STANDARD MACHINERY ARRANGEMENT FOR SMALL FACTORY.



H E Horizontal Engine.
L B Locomotive Boiler.
M S Mechanic's Shop.
L S Line Shaft.
D Dynamo for Lighting.
R 32-in. "Rapid" Rollers.
F R "Rapid" 10r Second Rolling.
P "Paragon" Dryers.
S B Storage Bins.
B Rolled Leaf Ball Breaker.
B S Balanced Tea Sifter.
T B Tea Breaking Machinery.
D P Double Tea Packer.
C S No. 3 Saw Bench.
T M Thicknessing Machine.
F B Fermenting Beds.
A P Air Propellers.
T R Tramway Rails.

FIG. 4.—STANDARD MACHINERY ARRANGEMENT FOR MEDIUM-SIZED FACTORY.



ENG Class C Engine.
L B Locomotive Multitubular Boiler.
E L Electric Lighting Engine and Dynamo.
T R Tramway Rails.
E M Tea Equalising Machines.
L E Green Leaf Elevator.
B B Rolled Leaf Ball Breakers.
R "Rapid" Tea Rolling Machines.
F R "Rapid" Rolling Machines for Second Roll.
F B Fermenting Beds.
P D "Paragon" Tea Drying Machines.
V D 72-in. "Venetian" Dryer for Final Firing.
B S Balanced Tea Sifting Machines.
D E Tea Dust Extractor.
D P Double Tea Packing Machines

FIG. 5.—STANDARD ARRANGEMENT OF MEDIUM-SIZED TEA FACTORY WITH MACHINERY.

The speed of main shafting is 140 revolutions per minute, and the same applies to Figs. 3, 4, and 5.

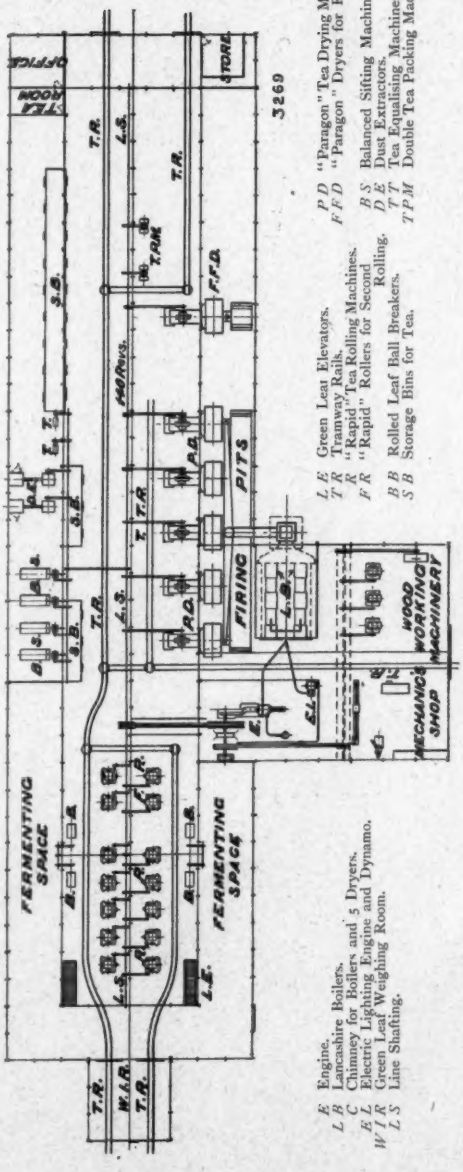
The introduction of machinery was of necessity accompanied by a demand for motive power, such hand-power and cattle-gear-driven tools for rolling purposes having been a subsequent innovation and found little or no favour.

Wind as an agent can never be relied upon, but it seems strange that more has not been done by way of utilising water, especially in so undulating a country as Cachar, with its average rainfall of 120 ins.

The late Mr. William Aitchison, of Doloo, in North Cachar, installed a turbine in the seventies. To secure the necessary volume of water a "bund," or embankment, was thrown across the one end of a hollow stretch of land some 20 acres in extent, thus storing a huge quantity of water for, at any rate, six months in the year. The motor employed was the outward flow vertical-shaft type, and it speaks well for Mr. Aitchison's forethought, when it is considered that the power required at Doloo is now three or four times greater than when the idea of utilising water-power was first conceived, while the services of an engine and boiler are only sought at the beginning of the season before the heavy rains set in.

With but some slight variations and improvements resulting from experience, a similar scheme was carried out at Hathecherra, also in North Cachar, with the same satisfactory economical results.

In 1885 a vortex turbine was established at the Cheerie Valley Tea Company's factory, but only a matter of 10 i.h.p. was aimed for; and as the requirements of the factory now amount to nearer 40 i.h.p., but a small



E Engine.
L B Lancashire Boilers.
C Chimney for Boilers and 5 Dryers.
E L Electric Lighting Engine and Dynamo.
W I R Green Leaf Weighing Room.
L S Line Shafting.

L E Green Leaf Elevators.
T R Tramway Rails.
R "Rapid" Tea Rolling Machines.
F R "Rapid" Rollers for Second Rolling.
B B Rolled Leaf Ball Breakers.
S B Storage Bins for Tea.

P D "Paragon" Tea Drying Machines.
F F D "Paragon" Dryers for Final Drying.
B S Balanced Sifting Machines.
D E Dust Extractors.
T T Tea Equalising Machines.
T P M Double Tea Packing Machines.

FIG. 6.—STANDARD ARRANGEMENT OF MACHINERY FOR LARGE TEA FACTORY.

portion of the machinery can be driven by it.

At the Tukvar Company's estate, in Darjeeling, a very meritorious piece of work is to be seen. The water from a mountain stream is collected and carried some three-quarters of a mile in a trough composed of wood or masonry, to suit circumstances, to a reservoir at a height of some 50 ft. above where the turbine is fixed, at an elevation of about 2,000 ft. The type of motor is the vortex horizontal shaft. The power to be transmitted to the factory, situated at an elevation of 4,700 ft., is conveyed by wire ropes running over grooved pulleys raised up on masonry columns or wood trestles at suitable distances apart. The whole scheme was planned and erected by the late Otto Möller, the company's engineer.

Regarding electricity — some enterprising individuals may yet propound a scheme for the purpose of establishing large generating stations, for which the torrents of the Rangheet and Teesta and other rivers in the Himalayas may be brought into requisition. The idea is, however, a remote one, but far from being impossible.

Obviously, steam became the universally prevailing power, and its best means of employment has called for some considerable attention. In the early days of the introduction of machinery some disgraceful specimens of engines and boilers were sent out to the East. They were qualified to claim the names, and that is all that can be said of them; happily, they have long since been accorded an ignominious burial, literally speaking, as they were eyesores above ground, and would not pay to despatch to some manufacturing centre for sale as scrap.

It was well for the tea industry that the production of the earlier inventions in tea machinery soon fell into the hands of a sound firm of engine builders; and a pardonable tribute may even, perhaps, be paid to them in these pages, for saving the engineer and planter, exiled in the jungles, a vast amount of worry and anxiety.

In the matter of the selection of an engine and boiler, the power required having been considered, the question of transport is one of importance, where roads are bad, and traction concentrated in an elephant or the native labour-force. There are few factories requiring boiler power of more than 40 n.h.p., at any rate, in one plant, and where close to a railway or steamer system the Cornish or Lancashire may be the most suitable, but where factories are miles away from either, the loco-multitubular boiler is, in every way, the better selection; as, mounted on temporary travelling wheels, with a pair of rough shafts, should an elephant be available, a long and very bad road can be traversed without serious delay and trouble, all things considered. The task of the European in charge is, at the best, a wearisome one. Small bridges and culverts are not constructed to carry 9 or 10 tons, while rivers of any width have to be forded. The sagacity of that unwieldy creature, the elephant, when harnessed to a boiler, is truly remarkable, and requires ocular demonstration to admit of even only partial credence.

The available attendant is not of a very highly-skilled class, so that the less complicated the prime mover in a factory the better; condensing engines, simple or compound, are therefore doubtfully economical. Fuel, whether coal or wood, is comparatively cheap; about 14*s.* a ton for the former, at any steamer ghat (station), on the Barak or Brahmapootra, while a stack of the latter, 4 ft. by 3 ft. by a convenient length 20—24 ins., is a day's work for an able-bodied man at the wood shed, wage 3 pence. The coal is small and bituminous, and requires careful stoking, or the plates in the fire-box are soon affected; it, however, gives excellent results when used with wood, and a very little care will prevent any waste whatsoever.

Space is no great object in a tea factory, and a few square feet, more or less, for the engine room, is not a serious item; so that the vertical types of either engines or boilers are not in any demand. The portable, from its name, has secured many buyers; but, as the engine is stationary after it is once in position, the advantage of being portable is not, therefore, one of

great moment, while its weight can never be reduced to that of a loco-multitubular boiler of equal dimensions. Cleaning and attention are also simpler matters, with the independent fixed type of engine.

The undertype, or Robey engine, continues to find many admirers, owing to its compactness.

The balance of opinion, therefore, is in favour of the horizontal fixed engine, of the self-contained pattern, up to 12 n.h.p.; over that, the choice lies between the high-pressure single-cylinder long stroke, with outside pedestal bearing up to 20 h.p. When more than this is wanted, a right and left hand engine may be coupled, with the fly-wheel between them. During recent years, however, boilers have been constructed of higher pressure, and the compound non-condensing has proved very satisfactory for 16 n.h.p. and upwards. The manufacture of tea machinery is almost entirely in the hands of the leading engine-makers, so that the results are now practically all that can be desired. An efficient feed-water heater has the advantage of effecting a saving in fuel. The feed water, however, is rarely below 80 degs. Fahr., and is, for the most part, free from lime.

A reliable governor gear is an important factor, both as a means of effecting a further saving in fuel, and controlling the speed of the engine, the load being subject to constant and sudden variations. Moore's patent crank-shaft governor is certainly one of the best for small engines. and Hartnell's automatic expansion gear for the larger sizes.

As anything in the shape of complication, in respect to shafting and gearing, is both unnecessary and undesirable, it is always avoided as far as possible; a main shaft running as far along the centre of the house as may be required, being the most usually adopted arrangement. A greater diameter than the transmission of the power used is calculated to demand, has gained favour in the past; the reason for this being the impracticabilty of getting a length of shafting under 3 in. draw, and over 12·14 ft. long, landed on to a factory dead straight. With few exceptions, tea machinery is driven direct from the main shaft, for which a speed of 130 to 150 revolutions per minute is the best suited. Apart from the fact that, by far the greater tea area is in districts where water is certainly not more than 3 or 4 ft. from the surface after the rains set in, in so far as out of sight is out of mind, and the belts are a source of danger to the hands employed, underground shafting is a mistake.

The centre H-iron columns of an ordinary double or three-storied building lend themselves perfectly to overhead shafting; but as there is hardly a spot where stone, in some form or other, is not present, and sand is abundant, concrete pillars of from 2 to 3 ft. high can be made, as they form excellent pedestals, and they are at the same time economical.

The many useful hints on belting. and the management thereof, are not of any great assistance to the user of tea machinery, dealing as they do mostly with leather. This material, as a means for transmission of power, owing to the humidity of the climate in which tea grows and flourishes, is the least suitable. Vulcanised india-rubber coated canvas is in every respect preferable to leather, although, all things considered, the balance of opinion is in favour of sewn cotton canvas belting throughout the factory.

The difference in running of cotton belting in wet and dry weather is very palpable, and occasions some trouble, if measures are not adopted to avoid this contingency; the hotter and dryer the atmosphere, the more the material stretches, and takes up accordingly when cold and wet.

Given, therefore, an engine making 90 revolutions per minute, with a 60-in. pulley, driving on to a 38-in. pulley on the line shaft, the requisite speed of 140 revolutions per minute is attained, and the diameters are such as to afford a good belt area. The fitting of a new belt should always be carried out in the dry season, before manufacturing commences. It is an admitted fact that the most effective belt tightener is the weight of the belt on the slack side,

which increases adhesion by increasing circumferential contact with the pulleys. The belt may be joined up with a lap, having a good margin of slack, which will take up in damp weather, so that very little slack is noticeable; the distance between the centres should not be less than 20 ft., while there is no necessity for anything beyond 25 ft. A belt applied in this manner, therefore, gives equal satisfaction at all times, and is never subjected to any undue tension.

The subject of jointing belts is one claiming more attention than is very often bestowed upon it; for the main drive, the lap is the most suitable, while butt or flush joints are to be preferred for the remainder. There are several belt fasteners, many of them attaining excellency, but as they all necessitate the use of a hollow punch, much is detracted from their efficacy. Punching a hole in a canvas belt means cutting the threads, which, if not wholly, is, in a great measure, obviated by the use of a tapered awl.

Raw hide laces, cut to a fine point, can be induced through the holes, thus avoiding the risk of fraying; it is a somewhat laborious sort of job, and requires careful supervision, but it has its reward. The very best laces procurable only should be employed and supplied direct from home, and, on their arrival at the factory, should be kept coated with castor oil until required for use.

Without in any way minimising the importance of any one of the processes in the manufacture of tea, withering must be admitted to a claim for a very large share because no amount of subsequent care will remove the defects in improperly withered leaf—and at this the initial stage the first obstacle to the clock and thermometer millennium is met with.

Imprimis, the object of withering is to "limp" or soften the leaves and stalks by evaporating the superfluous moisture and so render them pliable and yielding to the rolling and twisting process, and admit of bruising without breaking—in addition, withering is the preparatory stage to the fermentation which sets up in the course of and follows the rolling.

For many years past, no doubt has been allowed to exist on two points, viz. that the desired stage of wither should be accomplished somewhere within twenty-four hours—and it should be attained naturally, without the aid of the sun's direct rays or artificial heat.

Various forms of withering houses have from time to time been adopted; perhaps one of the oldest is that consisting of a series of changs (Assamese), machans (Hindustani), or platforms, one above the other, on which the leaves are spread and gradually wither or dry.

A narrow building, not more than 13ft. wide, with racks on either side, having wire stretched to carry trays or any other arrangement for spreading the leaf, is an excellent form of withering house. Space, however, has to be considered, as not more than 1000 lbs. of leaf can be accommodated per 100 ft. run in such a building.

(To be continued.)

H. J. Keatinge Green

The Load of a Locomotive.

By R. GORDON SHARP.

PRIMARILY the power of the locomotive is dependent upon four elements—viz., pressure of steam, diameter of cylinders, stroke of piston, and diameter of driving wheels. A direct comparison of the tractive power of engines may be obtained by simplifying the following expression—viz:

$$\frac{(\text{Dia. of cyls.})^2 \times \text{nom. steam press.} \times \text{stroke of piston}}{\text{dia. of driving wheels.}}$$

Of course using the same units throughout—usually pounds per square inch for pressure, and inches for dimensions.

A comparison made in this way is not absolutely correct, because there are so many conditions which affect the power either directly or indirectly, such as the adhesive weight, the point in the stroke at which steam is cut off, the back pressure due to the exhaust, and the general efficiency of the engine.

Lately the size and steaming capacity of the boiler has been receiving a great deal of attention; and, indeed, this is held by some authorities to be the real measure of the power of a locomotive. It is somewhat difficult to understand how extra boiler power should make any improvement in this direction, unless in cases where the steam supply, or adhesive weight, had previously been inadequate. If the matter were fully investigated it would be found that in many cases where the boiler had been enlarged without altering the wheels and cylinders, any increase in the power of the engine has really been due to the increase of steam pressure which has accompanied the increase of the size of the boiler. It is obvious that the lighter the boiler can be, so much the better will it be for the hauling power of the engine; more of its power will be available for pulling the actual paying load. It is wasteful to run a heavy engine and tender where a light one will do the work and is available.

A considerable portion of an engine's power is used up in dragging itself. An engine which in ordinary working would consume on an average, say, 35 lbs. of coal per train mile, would use from 7 lbs. to 10 lbs. of this on itself—that is, about one-fourth of the total. Hence the great effort—apart from the question of wages, oil, etc.—which is at present being made to construct engines which will be able to work heavy trains unaided. Piloting, or "double heading," makes very expensive working, especially when coal is dear. Quite recently an increase of 50 per cent. on prices would be equal to a loss of ½ per cent. dividend to railway shareholders.

The following is the well-known formula for finding the tractive power of a locomotive in lbs.:

$$\frac{d^2SP}{D}$$

where d = dia. of cylinder in inches,
„ D = dia. of driving wheels in inches,
„ S = length of piston strk. in inches,
„ P = mean effective steam pressure in the cylinders in lbs. per square inch.

The friction in the mechanism of the engine—valves, cranks, etc.—absorbs some power, and it is therefore necessary to make a deduction, which brings down the effective tractive power to about 90 per cent. of that given by the formula, and it therefore becomes

$$\frac{d^2SP}{D} \times \frac{9}{10},$$

which gives the amount of power available for moving the engine and train along the line.

So far the question of the load of a locomotive is very simple, but when we come to consider the resistance of the engine and train great complications present themselves.

Before the days of high speeds and

heavy loads it used to be common practice to estimate the load of an engine by assuming a speed of 10 miles per hour and allowing a tractive force of 6 lbs. to 8 lbs. for every ton in the train, including the weight of engine and tender. In that case the load in tons which a given engine would haul on the level at 10 miles per hour would be

$$\left(\frac{d^2SP}{D} \times \frac{9}{10} \times \frac{1}{8}\right) - \left\{\begin{array}{c}\text{weight of engine}\\ \text{and tender.}\end{array}\right.$$

As the speed increases so do some of the resisting forces, such as that due to the air, the curves, and what is caused by the rolling or oscillation of the vehicles. The internal resistances of the engine, and that due to friction of the bearings of the vehicles, remain fairly constant at all speeds.

If the speed of a train is to increase, the drawbar pull must be slightly in excess of the train resistance, else the speed will either remain constant or fall.

Taking everything into account, it seems to be a fact that there is a greater train resistance at high than at low speeds. The best way of showing this is by means of the accompanying diagram, which has been made up from data taken from some experiments made on the Midland Railway by Mr. R. M. Deeley, of the Midland Railway Locomotive Department. The resistance per ton of train can be very readily measured from the diagram for any speed on any incline given on the diagram. For example, if it be required to ascertain the resistance up an incline of 1 in 150 at a speed of 50 miles per hour, measure the vertical distance from the curve upwards to the horizontal line marked "up 1 in 150," and on applying the distance thus found to the scale of pounds it will be seen that the resistance is 27 lbs. per ton. At the same speed on the level it would be 12 lbs., while down 1 in 300 it would be $4\frac{1}{2}$ lbs. (nearly); and if the same speed were to be maintained down 1 in 150 the retarding effect of the brakes would have to be equal to 3 lbs. per ton (nearly). Examples might be given to any extent, but the foregoing will serve to show the scope of the diagram. It should be borne in mind that when it is necessary to measure downwards from the curve to any inclination or gradient line it always indicates that the effect of gravity is in excess of all the resistances in the train, and consequently, if the given speed is not to be exceeded, a retarding force will have to be applied in order to prevent acceleration.

The force in pounds per ton for any gradient is 2,240 divided by the distance in which the incline is unity; thus the force on

$$1 \text{ in } 100 = \frac{2{,}240}{100} = 22{\cdot}4 \text{ lbs.}$$

Knowing this, it is an easy matter to add any desirable gradient line to the diagram.

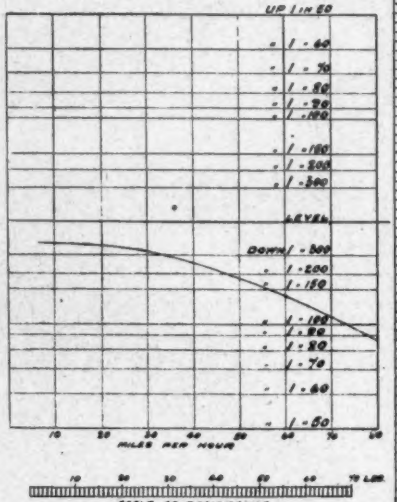
The condition of road and weather exercise a great influence on train resistance. If the road has many sharp curves the resistance may be increased 50 per cent from what it would be on a straight, level road. If, in the example taken above, the road were of a curved nature, the train resistance might be taken as

$$27 + \frac{12}{2} = 33 \text{ lbs., instead of } 27 \text{ lbs.}$$

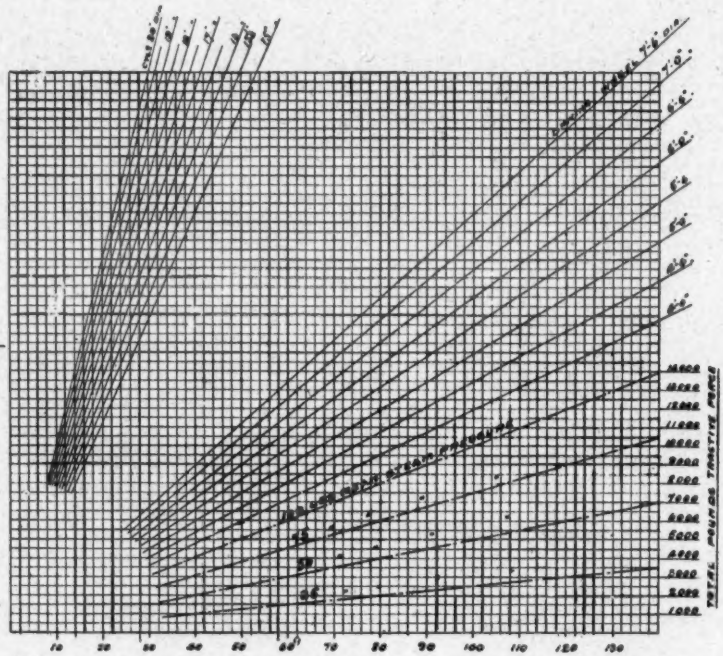
The total 27 is made up of 15 lbs. for gravity and 12 lbs. for other resistances. Gravity remains constant under all conditions.

In making up a load table for any part of a railway, due allowance must be made for the prevailing weather. If side and head winds are of frequent occurrence, a large margin of power is usually provided; but in cases where anything of the kind is unusual, it is accepted that vagaries of weather will simply affect the punctuality of the trains for the time being.

It is seldom possible to ascertain the actual weight of a train, but if the number of pairs of wheels (exclusive of the engine) be counted and 5 tons be allowed per pair, a very fair estimate of the weight of a passenger train can be made; or another approximation can be got by allowing $\frac{1}{2}$ ton per foot length of carriage. It is still more difficult to get at the weight of the engine, but a rough approximation can be got by allowing $4\frac{1}{2}$ tons per inch diameter of cylinders in the case of an engine and tender for passenger train working. That is to say, an engine



TRAIN RESISTANCE DIAGRAM


CUT OFF
TOTAL PRESSURE PER SQUARE INCH
MEAN EFFECTIVE STEAM PRESSURE
TOTAL PRESSURE TRACTIVE FORCE
10 20 30 40 50 60 70 80 90 100 110 120 130
STROKE OF PISTON IN INCHES AND TRACTIVE FORCE PER POUND OF STEAM PRESSURE

3173

TRACTIVE FORCE DIAGRAM

and tender in working order having 18-in. cylinders would weigh about 81 tons.

The second diagram gives a very simple and convenient means of finding the tractive power of all ordinary-sized locomotives. For example, in order to find the tractive power of an engine having 18-in. cylinders, 26-in. stroke, and 6-ft. driving wheels, assuming that the effective mean pressure is 100 lbs. per square inch, find where the oblique line marked 18-in. cylinders cuts the vertical line which indicates the length of stroke 26 ins. From this point move horizontally to the right till the oblique line marked 6-ft. wheels is cut, thence move vertically downwards till the dot-and-dash line marked 100 lbs. steam be cut, and then read off the tractive force, 11,700 lbs., on a level with this point, as shown by the scale at the right of the diagram.

If it were required to find the dimensions of an engine which would give 11,700 lbs. tractive force, it would be quite easy to read the diagram in the reverse direction. If this be done, assuming the same steam pressure for simplicity, it will be seen that an engine with 15½-in. cylinders, 26-in. stroke, and 4½-ft. drivers would develop almost exactly the same tractive force.

The convenience of a diagram of this kind will be appreciated by those who may have to design engines with certain given power, and by those who have the selecting of engines for certain work.

It may be remarked that the reading of the diagram cannot be quite accurate, but it can be to within 1 to 1½ per cent. of the exact figure without difficulty, which is quite as near as there is any practical use of, seeing that everything in connection with locomotive power and train resistances are but approximations at the best. Any remaining scruples ought to be at once removed when it is remembered that an allowance of 10 per cent. has to be made after reading off the total, in order to provide for the power necessary for overcoming the internal resistances of the engine, as already mentioned. Above all this, it must be borne in mind that the actual dimensions of a locomotive are constantly changing. No sooner is the engine at work than wear of cylinders and tyres takes place, both of which tend to make the tractive force become greater, and every time the cylinders are re-bored or the tyres re-turned the power of the engine is appreciably affected. While this is the case the nominal dimensions remain the same, and no account is taken of these changes which occur in ordinary working.

Considering the power of the locomotive generally, it may safely be assumed that the maximum has been reached so far as this country is concerned. Engines cannot be made larger than some existing examples, unless the bridges, platforms, etc., be altered, which is very unlikely, seeing that these engines can pull trains which are quite as long as can be handled by the train staff without serious confusion and consequent loss of time at stations.

There are engines now running which can take a train of 300 tons, exclusive of the weight of the engine and tender, along a straight, level road at the rate of 50 miles per hour for as long a time as the supply of coal and water will hold out. This may not appear at first sight to be very remarkable, but it must be observed that this is no spurt, but a long sustained effort. The same engine is quite capable of developing over 1,000 i.h.p.

R. G. S.

Some Recent Machinery Exhibits

of Messrs. D. Stewart & Co., Ltd., Glasgow.

❀ ❀ ❀

1. AIR COMPRESSOR.

THIS machine is of the compound vertical inverted type, having steam cylinders 12 ins. and 24 ins. diameter by 12-in. stroke, and air cylinders 13 ins. and 22 ins. diameter by 12-in. stroke. As will be seen from the general arrangement, Fig. 1, the steam cylinders are supported at the back by strong cast-iron columns, which contain the guiding surfaces for the cross-heads, and at the front by polished steel columns, bound together by a strong cast-iron entablature. The air cylinders are placed directly above their respective steam cylinders, being supported therefrom by substantial mild steel columns. The whole structure is bolted to a cast-iron bed-plate, which contains the main bearings and surrounds the flywheels. The crank shaft is of mild steel, with cranks at right angles and webs forged solid. The high-pressure steam cylinder is fitted with an ordinary slide valve with a variable expansion valve of the Meyer type fitted to the back thereof, and the low-pressure steam cylinder has a similar attachment for steam distribution. Each piston rod is in one forging from the cross-head, through the steam cylinder, up to the air cylinder.

From the detail of the air cylinder given in Fig. 2, it will be seen that the inlet and delivery valves are placed in the covers at both top and bottom ends. Elaborate precautions are taken to ensure that the valves cannot by any possibility fall into the working portion of the cylinders. The moving parts of the valves, which are for the sake of strength made of manganese bronze, are held in position by springs whose tension is adjustable. The valve seats and guards are made of best phosphor bronze. The barrel of each air cylinder is surrounded by a water jacket, and there is also a tubular cooler through which the air passes on its way from the low pressure to the high pressure air cylinder. The air inlet valve on the low pressure cylinder has an automatic adjustment for controlling the volume of air passing, depending on the quantity required.

The compressor is designed for a steam pressure of 120 lbs., and, when running at

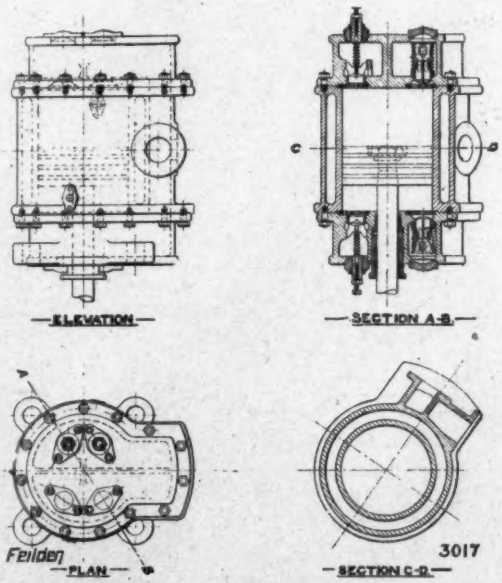


FIG. 2.—DETAILS OF AIR CYLINDER OF COMPOUND ENGINE.

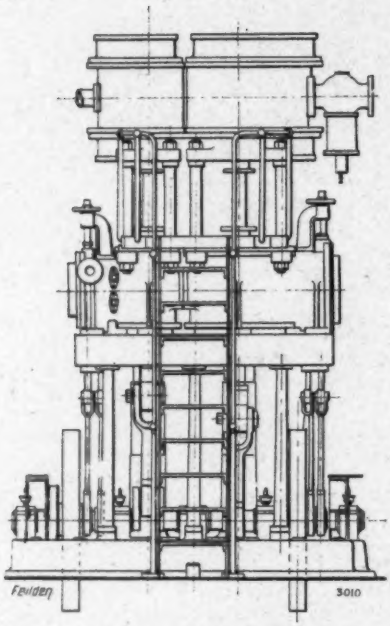
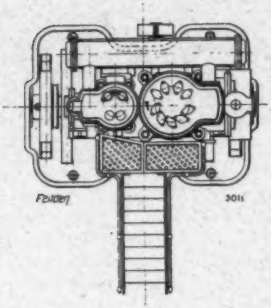
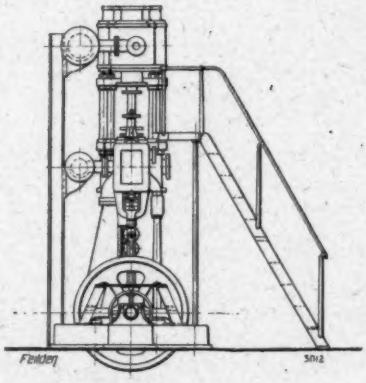


FIG. 1.—GENERAL ARRANGEMENT OF COMPOUND ENGINE AND AIR COMPRESSOR.





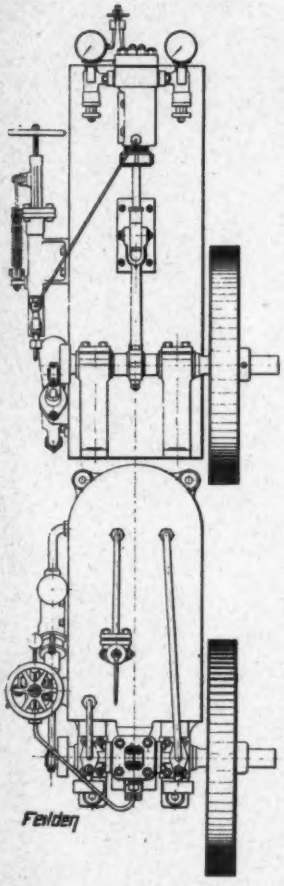
100 revolutions per minute, has a capacity of 400 cub. ft. of free air per minute, which it delivers at a pressure of 100 lbs. per sq. in.

2. ELECTRICALLY-DRIVEN CARBONIC ACID COMPRESSOR REFRIGERATOR.

This machine, the general arrangement of which is shown in Fig. 3, has an ice-making capacity of 5 cwts. per 24 hours. It is driven by an electric motor of 2·5 kilo-watts rating, through a single spur and pinion gear having a speed reduction of one to ten per cent. In order to diminish noise and vibration, the pinion is of raw hide, while the spur-wheel is of cast-iron with carefully proportioned teeth. The carbonic acid and brine circulating-pumps are both driven from the same crank-shaft, the former with axis vertical and the latter with axis slightly inclined to the horizontal. Each is bolted to a box-shaped casting, which also contains the condenser and refrigerating coils. The maximum pressure attained in the CO_2 pump is 80 atmospheres, and special attention is paid to the packing, so that it is comparatively frictionless and perfectly gas-tight. The lubrication used is glycerine, which is forced into the working parts by a lubricator, also attached to the main casting. The whole machine is self-contained and very compact; it can be used either for ice-making or cold storage. In the former case the ice-box, with the necessary coils, is placed as near the machine as possible, and in the latter the insulated refrigerating-room adjoins the machine and contains the brine circulating coils, arranged in any convenient way.

3. HEAHECH'S PATENT "HEAVY OIL" MOTOR.

This oil engine, as will be seen from Fig. 4, is of the two-cylinder type, with



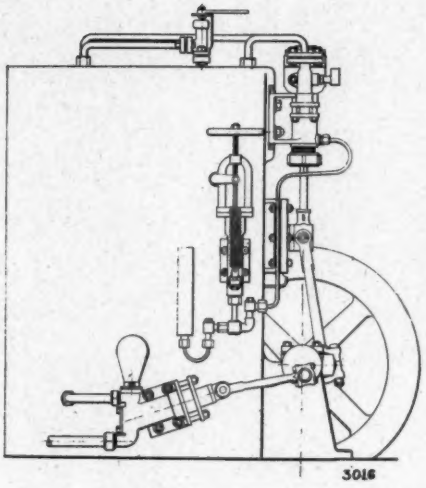
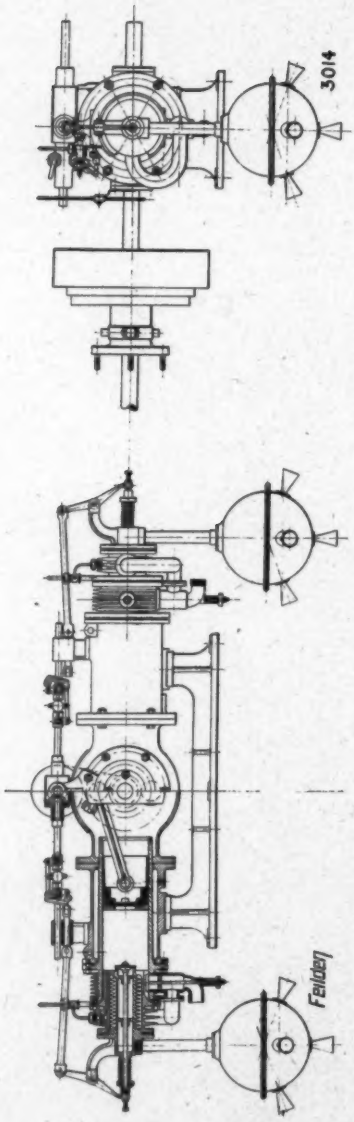


FIG. 3.—DETAILS OF ELECTRICALLY-DRIVEN CARBONIC ACID COMPRESSOR REFRIGERATOR.

cranks at 180 degs. The cylinders are 6-in. bore and 7-in. stroke, and the cycle is that first used in the "Otto" gas engine, the charges being drawn in, compressed, exploded, doing work, and exhausting in consecutive half-revolutions. The cycle in the one cylinder follows that in the other, being half a revolution later.

The main feature of this engine is the method of vaporising the oil. This is effected by distribution of the oil (ordinary paraffin) over a "gilled" vaporiser, contained in a chamber at the back of the cylinder and concentric therewith. The vaporiser itself is hollow, and the products of combustion pass from the cylinder through the central aperture. The vaporiser is so proportioned and constructed as to completely vaporise the oil during its flow by gravitation from the oil receiver. The rate of supply may be regulated by the governor or by hand, the vaporiser always being at the atmospheric pressure and in communication with the cylinder through a pipe which contains a simple non-return valve. The air necessary for combustion is also drawn through this same valve, and its quantity is regulated by a screw-down



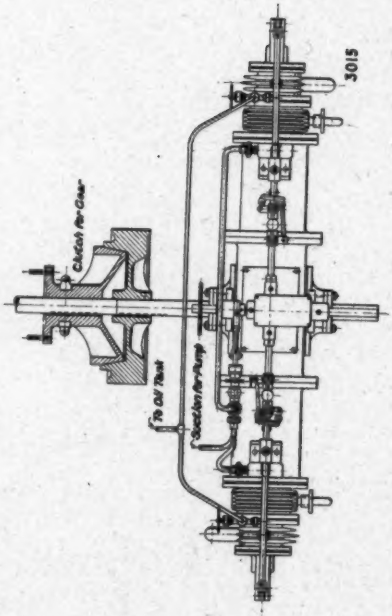


FIG. 4.—OIL MOTOR.

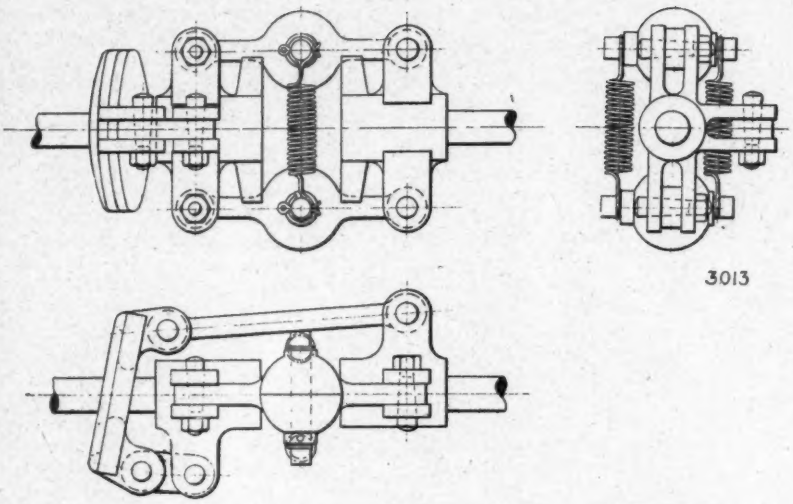


FIG. 5.—GOVERNOR ARRANGEMENT FOR OIL MOTOR.

valve under control of the operator. Exact adjustment is not necessary, as the engine works well during temporary changes of load without altering any of the valves. Release of the charge is effected by means of a valve on the same axis as the cylinder, and by closing the open end of the vaporiser. This motor is designed, and is particularly suitable for, a heavy class of mechanically-propelled vehicles.

B. T.

The Nicaragua Canal Project.

By JOHN GEO. LEIGH.

SOME readers of this article will probably recall to mind a paper which it was my privilege to contribute to the final number of FEILDEN'S MAGAZINE published in the last century.* In this I dealt at considerable length with the engineering and political history of a question which has since called for much public attention, receiving, however, far less than its importance properly claimed. Incidentally I sought to impress upon my readers a sense of the vast responsibilities and interests at stake should Great Britain fail to appreciate present facts and coming opportunities. I hinted not obscurely at grave dangers near at hand, and the surest means whereby they might be averted; and endeavoured to expose those current fallacies, economic and concerning the two principal rival projects, upon which our national apathy in the matter was largely based. Three months later, in the editorial pages, my arguments received substantial and forcible support; and the same may be said, so far as it related to British commercial interests, of the Marquis of Lansdowne's despatch to Lord Pauncefote of February 22nd of last year, which the Foreign Secretary practically repudiated in later correspondence and by his assent to the second Hay-Pauncefote Convention.

Since then much has happened to bring the subject prominently in the public eye. Always excepting the struggle in South Africa—for which, more than aught else, perhaps, we have to thank our unqualified surrender at Washington—the Isthmian Canal has been the one great vital question before the country. Of the management of the matter by those in authority I abstain from writing, because, as I understand, this question will be dealt with in another section. I may, however, be permitted to express surprise that periodicals, calling themselves "Imperialist" and claiming to have taken British commercial interests under their special protection, have either remained dumb throughout the controversy or, at best, evidenced no larger knowledge of or concern in the subject than were involved in saying "Ditto" to Lord Lansdowne and "the man in the street." The same thing may be said of our Chambers of Commerce and other associations more or less representative of commercial and industrial Britain. Their consistent self-effacement and preference to avoid discussion rather than run counter to what happened to be the fashionable fad are, in my opinion, sad signs of the times. To "play 'possum" at a period which may prove to have been critical in the history of British commerce is not the way to ensure efficient guardianship of the highest material interests of the nation.

Before this article appears in type the first steps may have been taken by Congress in the direction of what President Roosevelt, in his initial Message, emphatically and aptly described as "a work which it is for the interest of the entire country to begin and complete as soon as possible—one of those great works which only a great nation can undertake with prospects of success, and which when done are not only permanent assets in the nation's material wealth, but standing monuments to its constructive abilities." Six months ago nothing seemed so certain to the average man, English and American, as the canal programme of the United States when freed from the trammels of the Clayton-Bulwer Treaty. To write of the Nicaragua project as a phantasy, and of the Panama Canal as not only a tangible entity, but the probable adopted child of the United States, was to stamp oneself a lunatic; self-sufficient editors had heard that some years ago the

* "The American Isthmian Canal," December, 1900.

Americans intended, and had even commenced the construction of a canal in Nicaragua, and that, on the other hand, there had been scandalous revelations concerning Panama; their publications became vehicles for the diffusion of antiquated and misleading prejudices; and the few unhappy people who, by accident or study, happened to be able to discriminate between the fact and fiction of the subject were, rare instances excepted, laughed to scorn and denied even the politeness of a hearing. To these observations I must offer two additional remarks. The first is that they apply only to England—that Americans, although accustomed for three-quarters of a century to regard the Nicaragua route as the best available, and almost a national institution, have always, officially and as private individuals, been hospitable to contrary views and conclusions. My second is of more general character, based upon personal study of the commercial methods of the two peoples, and is to the effect that to the Englishman's exaggerated, even vaunted, distaste to receive new impressions, may be traced much of the acute rivalry of which our Trade Returns and contract lists so frequently bear witness. "Slow and sure" is an excellent motto, but one to be accepted with reservations, and the Isthmian Canal question seems to me a formidable case in point.

Of the circumstances attending the incorporation of the New Panama Company, the work accomplished by the latter, and the project for the completion of the canal, which had been recommended by the International Technical Committee, I wrote at some length in the article to which reference has been made. To bring the record down to date it is only necessary to state that the two latest American Commissions went over the route and workings and reported very favourably of the measures adopted by the Company to keep the enterprise alive. The second, or Isthmian Canal Commission, having been appointed "to make investigation of any and all practicable routes," and particularly those known as the Nicaraguan and Panama, very loyally fulfilled its mission. It completed the investigations with which it was charged towards the close of last year, and, in its report, dated November 16th, frankly recognised the many advantages offered by the shorter and partially completed undertaking. Although the report recommended the Nicaragua route as "the most practicable and feasible" for an isthmian canal, "to be under the control, management, and ownership of the United States," it also made clear the fact that this provision as to control, etc., had weighed with the Commission almost as much as the alleged "unreasonable" price fixed by the Panama Company for the sale of its property and franchises. The Commission adopted, as the basis of its technical recommendations for the completion of the Panama enterprise (should such an undertaking commend itself to Congress), the scheme outlined in this Magazine sixteen months ago, with, however, certain important modifications, all more or less dependent upon one heroic and conspicuous departure.

The Technical Committee of 1898 proposed that the bottom of the summit level of the Panama Canal should be 20·75 metres (68 ft.) above the mean level of the oceans, and that this central reach, cut through the Cordilleras, should have a length, between locks at Obispo and Paraiso, of about 6¼ miles. They, however, worked out a second plan, which they favoured, but did not recommend on account of the enormous additional excavation involved. This was to deepen the cut through the continental divide until its bottom was only 32 ft. above sea, to omit the two flights of locks which have been mentioned, and make Lake Bohio the summit level, fed directly by the Chagres. With these proposals, in the main, the American engineers are in accord. The principal difference between their plan and that of the International Committee is the increased height given to the Bohio dam, by which means it will be possible to increase the depth and area of Lake Bohio, materially reduce the amount of excavation through the continental divide, and take fuller advantage of favourable topographical conditions for the discharge of surplus waters. Lake Bohio would

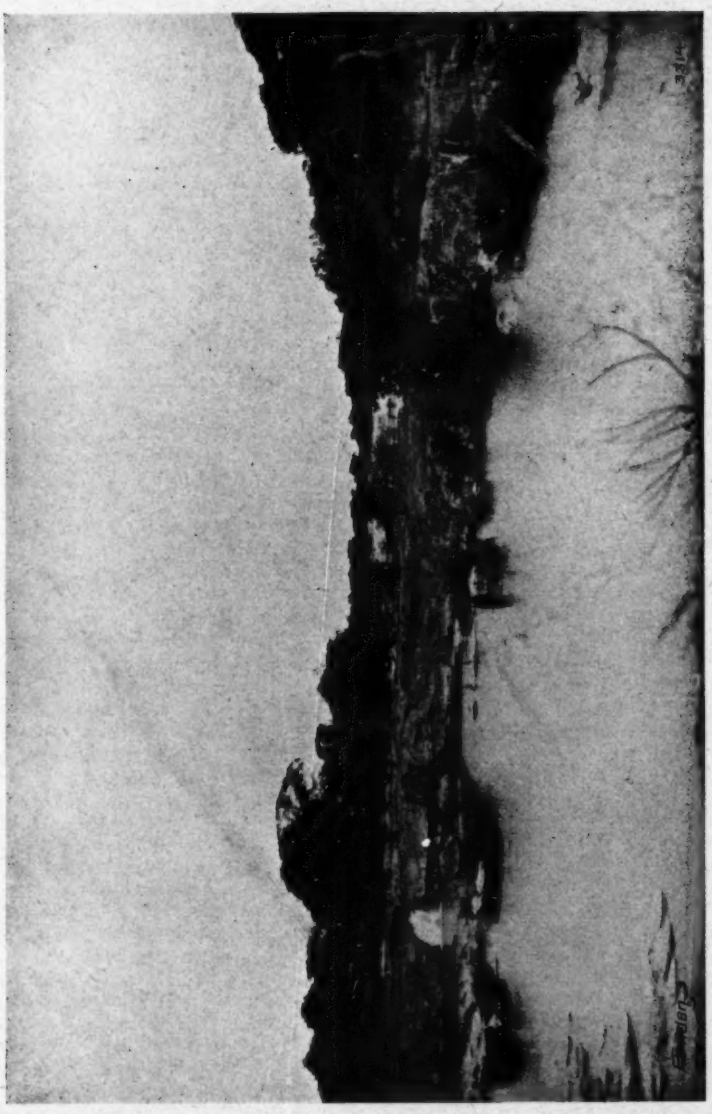


FIG. 1.—DAM SITE AT TIPITAPA, IN DRY SEASON.

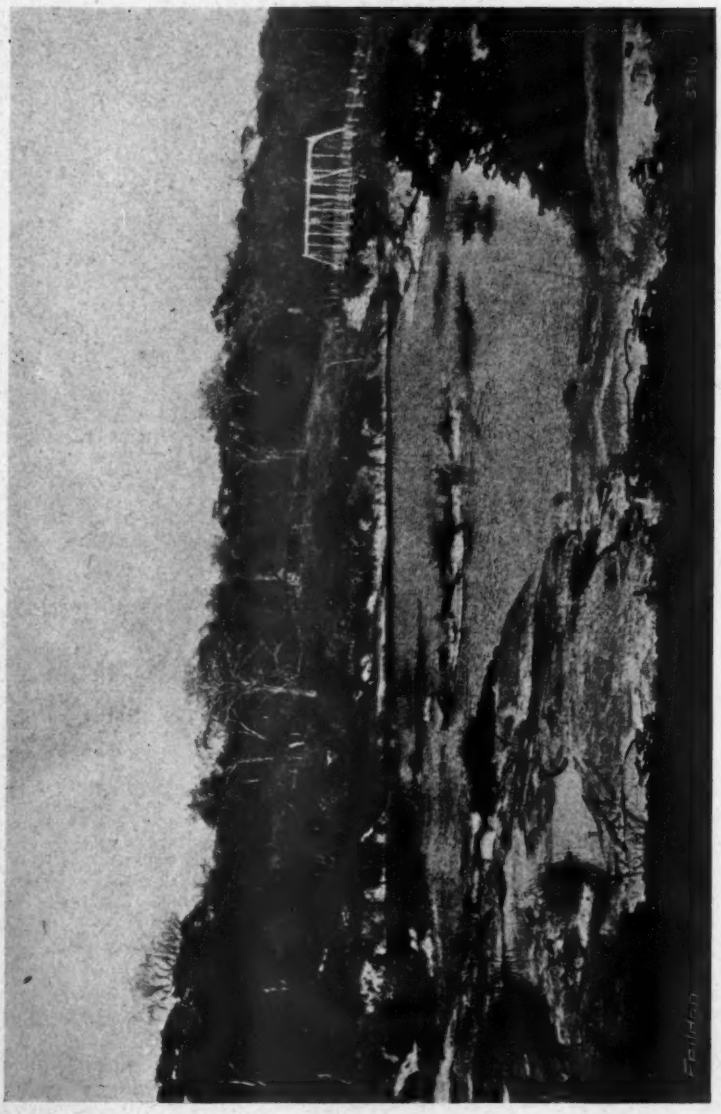


FIG. 2.—GAUGING STATION AT TIPITAPA.

FIG. 3.—ZAPATERO IN CLOUDS.

receive directly into it and without impediment to safe navigation the full floods of the Chagres, the Alhajuela dam would become unnecessary for flood control, and the Emperador-Culebra cut would be deepened only to elevation 47 ft. above sea, a very substantial consideration in the matter of cost. It is also proposed to place, at the site of the projected Obispo lock, a pair of steel gates, 100 ft. wide, so that, if it should ever be found necessary to draw off the water from the summit cut, the level of the artificial lake would not be affected. From these gates to Pedro-Miguel locks is a distance of 7·91 miles, and within this limit alone the amount of excavation still required is 43,237,200 cubic yards. Such a concentration is probably without precedent, and, as the American Commissioners point out, no work has ever been undertaken where practical engineering talent might produce greater economies. They estimate the cost of the 6·02 miles of heavy work at nearly $42,000,000, and of the entire section about $2,500,000 more.

Much time was devoted by the Isthmian Canal Commission to the acquisition of needful information concerning the Bohio dam, a vast structure, of vital importance to the scheme, and presenting not a few serious difficulties. For it a new site has been found, where the dam will necessarily be longer, but the greatest depth to rock is only 128 ft. below sea-level. Here it is proposed to construct an earth embankment, with a heavy masonry core carried down to bed rock the entire length of 2,546 ft. The foundation of the core would be sunk by the pneumatic process at all points where the rock is lower than 30 ft. below mean sea-level, *i.e.* for a distance of 1,314 ft.; elsewhere cofferdams would be used through a distance of 324 ft., and only above elevation 8 would the operations be conducted by ordinary dry-work methods. The total height of the dam above the lowest part of the foundation is to be 228 ft., equivalent to an elevation of 100 ft. above mean sea-level, and affording a super-elevation of 8 ft. above the highest possible level of the lake. It is proposed that the top width shall be 20 ft.; that the earth faces, heavily riprapped with rock spoil, shall have mean slopes of one vertical to three horizontal, and be broken by three terraces, each 6 ft. wide; and that the masonry

core shall be 30 ft. thick below elevation 30, tapering thence to 8 ft. at top.

Summing up the several figures contained in the latest American report, it is interesting to note that the total estimated cost of completing the Panama Canal, according to the Commissioners' plans, and with increased width and depth, equivalent to those proposed over the Nicaragua route, is $144,233,358 (£29,718,115), as against £20,378,577, the estimate of the *Comité Technique*. The former amount is thus made up:—

—	Miles.	Cost.
Colon entrance and harbour	2·39	$8,057,707
Atlantic section, including levées ...	14·42	11,099,839
Bohio locks, including excavation ...	·35	11,567,275
Lake Bohio	13·61	2,952,154
Obispo gates ...	...	295,434
Culebra section ...	7·91	44,414,460
Pedro-Miguel locks, including excavation and dam ...	·35	9,081,321
Pedro-Miguel level ...	1·33	1,192,286
Miraflores locks, including excavation and spillway ...	·20	5,781,401
Pacific level ...	8·53	12,427,971
Bohio dam	...	6,369,640
Gigante spillway ...	...	1,209,419
Pena Blanca outlet ...	...	2,448,076
Chagres diversion ...	...	1,929,982
Gatun diversion ...	...	100,000
Panama Railroad diversion	...	1,267,500
Total	49·09	$120,194,465
Engineering, police, sanitation, and general contingencies, 20 per cent....	...	24,038,893
Aggregate ...	...	$144,233,358

Although many surveys had previously been made of the route through Nicaragua, and at least a dozen estimates were in existence forecasting the cost of constructing a ship-canal across that region, it was reserved for the Nicaragua Canal Commission of 1897-9 to issue the first really reliable and comprehensive report on the subject. The preliminary statements of this body, published before its investigations were half-completed and evidently demanded for political reasons, contained little promise of the excellent final report which was to follow. Of this document, and its valuable appendices—engineers', geologist's, and hydrographer's reports, and route maps on a magnificent scale—very few copies appear to have been issued, and I am consequently doubly fortunate in the possession of one officially presented. Before this report issued from the press, a new Commission had been appointed, with enlarged membership and more expansive purpose. "The President trusts that the Commission will fulfil the important duties confided to them in such a manner that, when their report is prepared, it will embrace all the elements required for his own guidance and for the final action of Congress upon the subject of the location and construction of the interoceanic canal." With these words Mr. Hay concluded the letter addressed to Rear-Admiral Walker in June, 1899, which officially notified the President of the 1897 Commission of his appointment to another body intended to be the last of its kind. When Congress met in December, 1900, the preliminary report of the Isthmian Canal Commission was laid before it, and this was followed exactly

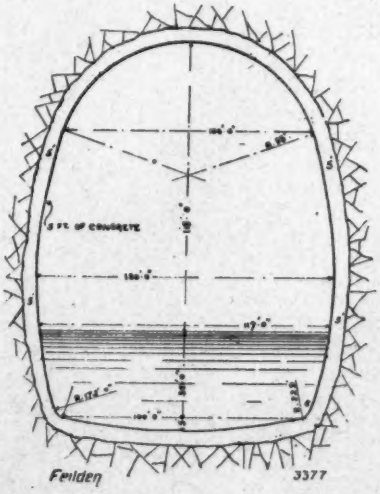


FIG. 4.—SECTION OF A SHIP CANAL TUNNEL.

a year later by the presentation of what purported to be the Commission's "final" conclusions, accompanied with reports, treaties, concessions, maps, plans, profiles, and the like—a veritable library of isthmian canal lore.

After examination of all the alleged "practicable routes," from the Isthmus of Tehuantepec in the north to the Atrato river in the south, the Isthmian Canal Commission has determined that there exist only two over which a canal of commercial utility can be constructed at reasonable cost Attractive as Tehuantepec is from a geographical standpoint, and therefore an excellent location for a trans-continental railroad, it has no merits as the possible site of a canal. Its broad summit is 700 ft. above sea, and to reach it there would be required on each side at least twenty locks, costing £40,000,000. The narrowest part of the isthmus south of Panama is known as the San Blas route. Here the distance from sea to sea is only 31 miles, but to divide the mountain chain, and supply the summit level with water, were it feasible to appreciably lower it, are regarded as insuperable achievements. The same difficulties appear in all the routes at the extremity of the isthmus, which have at some time or other commended themselves to promoters or engineers. Data are now available wherewith to explode many ancient fictions; and it seems certain that the adoption of any one of these suggested alternatives to Panama or Nicaragua must involve extensive tunnelling, objectionable for financial and more cogent reasons. With a view to determine the cost of a canal tunnel, the Isthmian Commission caused a section (Fig. 4) to be worked out, providing for a depth of 35 ft., a width of 100 ft. at the bottom and of 117 ft. on the water-line, and a height of 115 ft. from the water-surface to the intrados of the lining. The quantities and estimated cost per foot of such a tunnel, lined with 5 ft. of concrete, are :—

	£	s.	d.
676·2 cub. yds. excavation, at 20s. .	676	4	0
88·7 ,, ,, concrete, at 40s. ...	177	8	0

Or over £4,507,000 per mile!

The attractive features of the Nicaragua route are the Lake and the comparative facility of canalising the upper reaches of the San Juan River. The advantages of a natural summit level affording a constant and inexhaustible supply of water for the service of the canal cannot be lightly esteemed; on the other hand, there can be too much of a good thing, and it must be obvious that the control of such an enormous mass of water—with recorded level fluctuations between 98 and 112 ft. above the mean level of the oceans—involves the consideration of many most difficult problems. As indications of the magnitude of this question alone, without entering into such details as the conditions determining maximum and minimum elevations, rainfall, outflow, wastage and the like, at different seasons, the following figures will well repay consideration :—

Maximum dimensions of Lake Nicaragua	101 by 45 miles
Area of water surface, 2,000,000 acres	3,000 sq. miles
Approximate area of entire drainage basin	12,900 sq. miles
Area of Lake Managua ...	438 sq. miles
Elevation, above Lake Nicaragua, approximately ...	28 ft.

Put very briefly, the lake level requires to be controlled within such limits, more or less exact, as will never permit the navigable depth of the summit level of the canal to be anywhere less than 35 ft., nor, on the other hand, allow the lake to rise materially beyond a determinate elevation, fixed at 110 ft. above the sea. As a result of careful observations and elaborate calculations, the Isthmian Canal Commission has recommended an extension of the summit level, *i.e.* the surface of the lake, to a dam built across the San Juan River, 52·9 miles from the Lake. Over this arm of the lake, which the canal will leave at a point 3·3 miles from the dam, it is proposed to discharge the entire wastage of the lake—all the regulation works, including waste-weirs to the lower San Juan, being localised at or in the immediate vicinity of the Conchuda dam. With the lake at 110, and the pool immediately above the dam at 104, the discharge through the upper section of the canalised San Juan would be 63,000 cub. ft. per

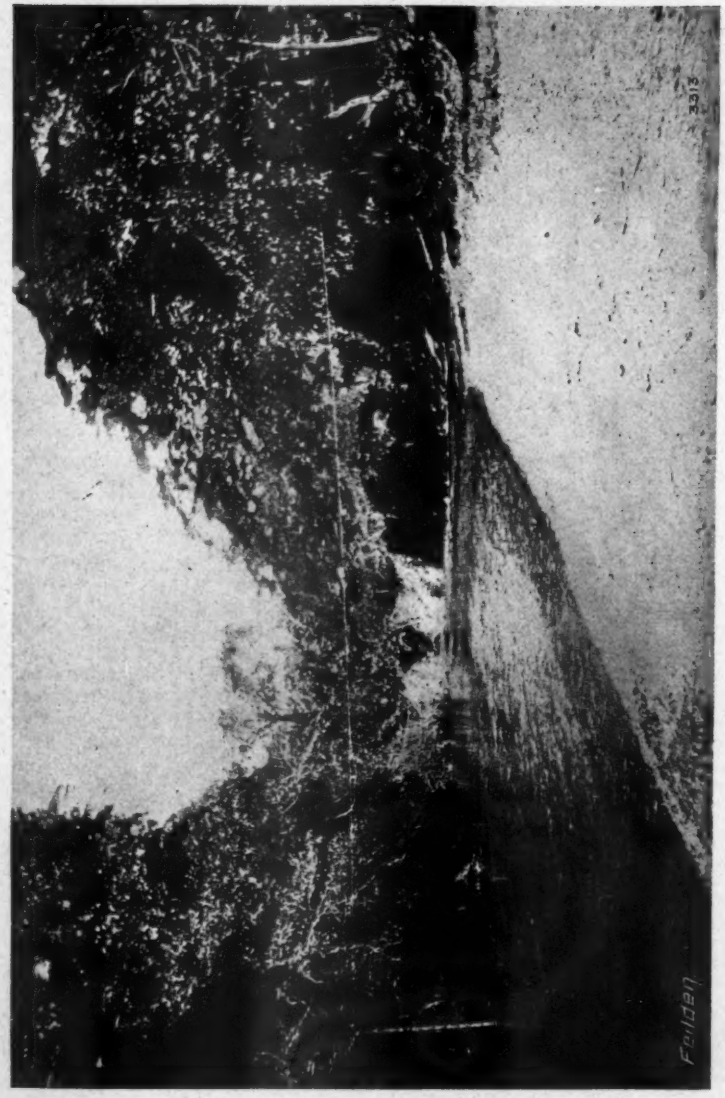


FIG. 5.—GAUGING STATION ON THE RIO GRANDE, NEAR BRITO.

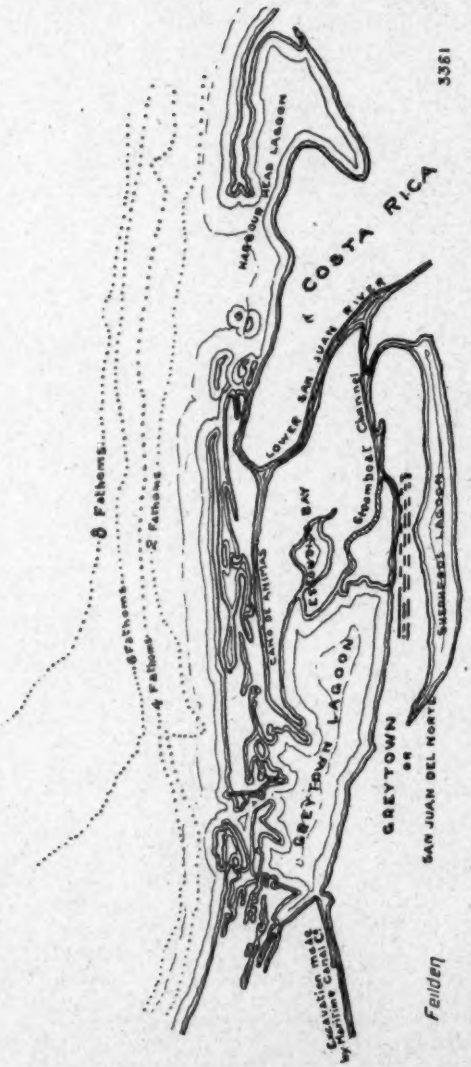


FIG. 6.—PRESENT CONDITION OF GREYTOWN HARBOUR.

second, but as allowance has to be made for a rise of the lake to 112, and a consequent increase of the discharge to 76,000 cub. ft. per second, the waterway at the dam is of such design as to be capable of dealing with a discharge per second of no less than 100,000 cub. ft. It has been deemed judicious to limit the water on the crest, under normal conditions, to 7 ft., fixing the crest of the wasteway at 97; for a discharge, therefore, of 100,000 cub. ft., with 7 ft. on the crest, a weir 1,500 ft. long will be required, and this is to be provided by placing on the dam 21 sluice gates, each of 30 ft. opening, and 32 others at a site some 2,500 ft. distant.

The site of the dam required as part of the regulating works has been the subject of much attention. The Nicaragua Canal Commission condemned the proposal of the Maritime Canal Company to locate this at Ochoa, and also took strong exception to those attractive but hazardous details of the Menocal project which would have necessitated numerous embankments across the river Danta, in the San Francisco region and other places. As a suitable site for a masonry dam, the Commission favoured a spot about 3 miles above the mouth of the Rio San Carlos, and this choice was confirmed in the preliminary report of the latest board of investigation. During the past year, however, borings on a more extensive scale have disclosed an irregular bottom with hard rock at a maximum depth of 60 ft. below sea-level, instead of 12 ft., as had been estimated. The latest choice, therefore, has fallen on Conchuda, where, it is stated, the greatest depth to hard rock is only 82 ft. below the surface of the river at low stage. The difference is important, for the foundations of the dam will most probably have to be placed by the compressed air process, and instances are by no means rare of the foundations of bridge piers having been built by the same method at an equivalent or greater depth.

According to the plan, the dam below low water will extend across the river and the swamp on the Costa Rica side, a total distance of 731 ft., and consist of caissons

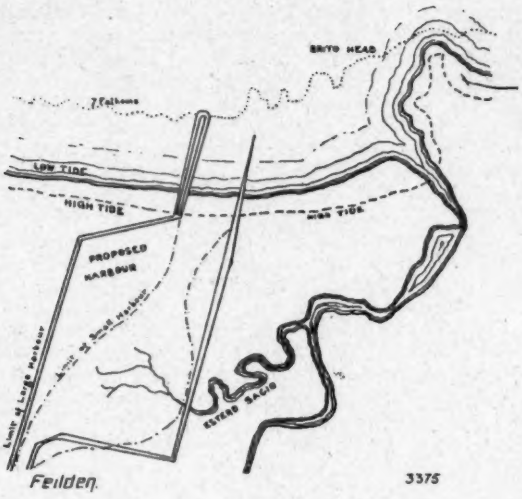


FIG. 7.—PROPOSED HARBOUR AT BRITO.

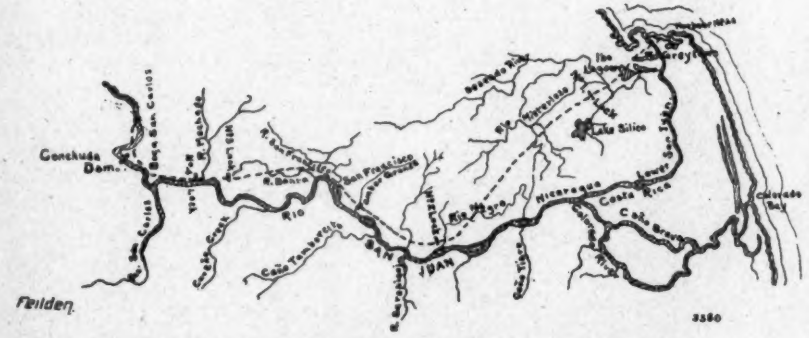


FIG. 8.—ROUTE OF PROPOSED CANAL FROM GREYTOWN TO THE SAN JUAN RIVER.

FIG. 9.—THE CANALISED SAN JUAN.

placed close together with sealed joints. Upon this platform will be built a continuous monolithic structure supporting the sluices already mentioned, and from each end of this portion the dam will extend for a distance of 100 ft. into the hillsides, with cross sections designed to sustain the full head of water. Core walls to a further distance are also proposed, of 100 ft. on the Costa Rica side, and 240 ft. on the other. Thus the total length of the dam will be 1,271 ft. It is suggested that this work can be built in four years, as against the eight years estimated in the preliminary report for the construction of the Boca San Carlos dam.

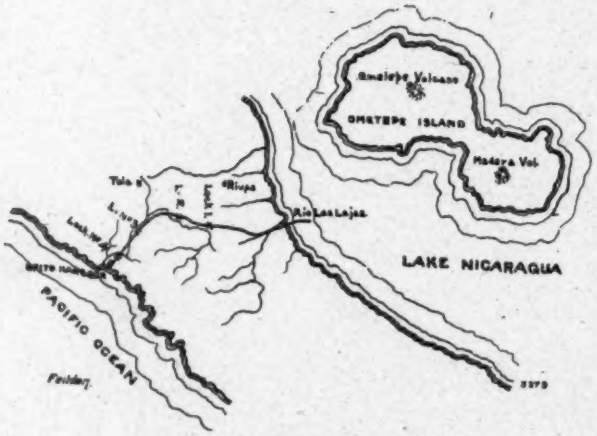


FIG. 10.—FROM THE LAKE TO THE PACIFIC.

A very important question in connection with the Nicaragua project is that of harbours. If the enterprise be undertaken, the existing lack of harbour facilities will be seriously felt, especially on the east side during the early stages of the work. There once existed a fair harbour at Greytown, with about 30 ft. of water in the anchorage and in the entrance. Thanks, however, to the sediment brought down by the San Juan River and the action of the ocean waves and currents, there have, during recent years, been a gradual shifting of the great sand-spit outside and a shoaling of the entrance, until its condition appears apparently hopeless (Fig. 6). The Isthmian Canal Commission, however, believes that if the westerly drift of sand can be stopped by interposing a jetty extending into the sea, there need be no difficulty (with continuous dredging such as is practised at the Mediterranean entrance of the Suez Canal) in maintaining an open channel on the lee side. It is therefore proposed, on the east side of the projected harbour and extending to the 6-fathom curve, to run out a jetty, built of loose stone resting on a suitable foundation, and covered with stone not weighing less than 10 to 15 tons irregularly deposited to break the force of the waves. On the west side also there should be a similar but shorter jetty. The harbour, as designed, will have a depth of 35 ft., a length of 2,500 ft., and widths of 500 ft. and, at the inner end, 800 ft. The Commissioners urge that there should be no delay in commencing operations at Greytown, as at least two years will be required to make the necessary preparations and construct an entrance and working harbour 18 ft. deep, the minimum which would afford reasonable facilities for the landing of material needful for the construction of the canal.

At Brito, the Pacific end of the projected canal, the conditions are somewhat more favourable. Here it is proposed to build a harbour (Fig. 7), with a single jetty reaching the 6-fathom curve 1,200 ft. from the shore line. The harbour itself will be 2,200 ft. long, with an extreme width of 800 ft. and entrance 500 ft. wide.

The Commission of 1897-99 adopted as the route of the canal practically that suggested by Colonel Childs in 1852, but all plans which appeared to involve

dangerous engineering works were rejected for others reasonably free from risk. Of the former some instances have already been mentioned, to which may now be added the La Flor dam, in the western, or Pacific, section. The latest project follows the same lines, with, however, certain modifications — increased depth of water, duplicated and enlarged locks, the elimination of two locks in the Greytown-Boca San Carlos section, and a new site for the great San Juan dam.

From Greytown the line passes through a region covered in places with swamp grass, in others heavily timbered. For a considerable distance, and elsewhere very frequently until the summit-level is reached, it will be necessary to protect the canal against flood-water with embankments on both sides. The cut in the Tamborcito ridge is the deepest in this section, and will consist largely of hard, basaltic rock; westward from lock No 3 the excavation will be mainly in firm earth and rock, and after lock No. 4 the line passes through a rough, hilly country where deep cutting will be encountered. Lock No. 1 will have a lift of 36½ ft. above mean low tide; No. 2 one of 18½ ft., from elevation 36 to 54·5; Lock No. 3, 18½ ft., to elevation 73 at minimum canal level; and Lock No. 4, one varying from 31 ft. minimum to 37 ft. maximum. The last-mentioned is designed to control the summit-level between the elevations 104 and 110, as already explained. A map of this section (Fig. 8) will be found on another page.

The point where the canal enters the San Juan is 46·17 miles by the canal line from the 6-fathom curve outside Greytown. Thence, for nearly 50 miles to Lake Nicaragua, the line closely follows the course of the Rio San Juan. Though the river above the mouth of the San Carlos is fairly free from sediment and, in this respect at least, well adapted for

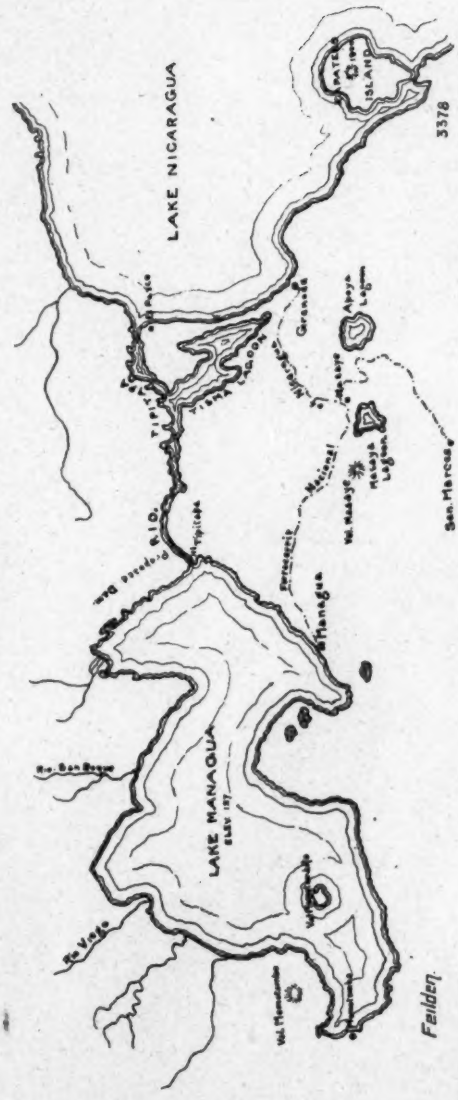


FIG. 11.—LAKE MANAGUA.

slack-water navigation, the curves are frequently so sharp that the natural channel, even if deep enough, would be prohibitive of the passage of large ships. Therefore, in many places, some of which are indicated in the map of this section (Fig. 9), cut-offs are proposed. These will, of course, materially improve the course of the channel, but even with them quite 54 per cent. of the entire distance from the dam to the lake will be left in curvature. Though the curves in this project are of larger radius than we have been accustomed to in reports dealing with the Nicaragua route, they cannot be pronounced quite satisfactory; there are seven instances where the radius is below 5,000 ft., and between Machuca and Castillo Rapids this limit is reduced to 4.045 ft. In places considerable rock will have to be excavated, sometimes under water, as between Castillo and the head of the Toro Rapids.

The bottom of the lake from Fort San Carlos to deep water consists of soft mud lying on clay and sand, and will certainly call for some expense for maintenance after a channel is excavated through it. The sailing line on the lake is 70·51 miles in length, with a bottom width in excavation of 300 ft.; and no fewer than 28·73 miles, including 1½ miles through rock on the west side, will require excavation.

In the Pacific section (Fig. 10) the most important feature is the cut through the mountain chain. Its maximum depth on the centre line of the canal appears to be 87 ft., the average for about 3 miles being 75 ft. The divide is reached at elevation 153, about 5 miles from the lake shore. On the south side of lock No. 5, which will have a variable lift from 22½ to 26½ ft., depending on the height of the lake, a small earth dam with a masonry core wall extending to rock will be built across the Rio Grande to the adjacent hills, for the purpose of maintaining the summit level. Between this point and Lock No. 7 a number of embankments and other structures will be necessary for the diversion of the Rio Las Lajas and Rio Grande, flood regulation and the like. Locks Nos. 6 and 7 will have lifts of 28½ ft., but the lift of lock No. 8 will vary with the tide from 28½ ft. at mean low water to 20½ ft. at mean high water.

In the report of the Nicaragua Canal Commission I find mention of a suggested dam across the Rio Tipitapa between Lakes Managua and Nicaragua (Fig 11), but no reference to the matter appears in the later report; and it must, therefore, I suppose, be assumed that this structure is no longer deemed essential.

For construction purposes a railroad will, of course, be necessary; and provision appears in the report for lines between Greytown and the mouth of the Sabalos River, from the latter point to the Conchuda dam site, and from the west shore of the Lake to Brito.

Having collected the various items, it appears that the total estimated cost of constructing a canal across the Nicaragua route is given in the table on the next page.

This, it must be remembered, is an "estimate," and not unlikely to be subject to those accidents which usually befall other compilations of its kind. Speaking of the scheme as a whole, it is impossible to avoid the conclusion that the Commission has been unduly optimistic, both as regards the difficulties to be encountered and the cost of overcoming them. Most assuredly is this the case in connection with Greytown Harbour, the total cost of constructing which is estimated at about £474,000, or rather less than one-fourth of the provision for improving the already existing and fairly safe and commodious harbour at Colon! It is possible that, at enormous cost, a canal may be built across Nicaragua; but it is very questionable if, when completed, it would be of great commercial utility. That it would be difficult of navigation is already certain, and so also is the fact that the minimum time required for transit would be 33 hours of daylight—in other words, from three to four days. Moreover, before a fair comparison can be instituted between the above estimate and that of the same Commission for the completion of the Panama undertaking, several important facts should be taken into consideration. Although the Commmission recognises the great

ESTIMATED TOTAL COST OF NICARAGUA CANAL.

—	Miles.	Cost.
Greytown harbour and entrance	2·15	$2,198,860
Greytown harbour to Lock No. 1, including approach wall to lock	7·44	4,899,887
Diversion of Lower San Juan	—	40,100
Diversion of San Juanillo	—	116,760
Lock No. 2, including excavation	·20	5,719,686
Lock No. 1 to Lock No. 2, including approach walls, embankments, and wasteway	10·96	6,296,632
Lock No. 2, including excavation	·20	4,050,270
Lock No. 2 to Lock No. 3, including approach walls, embankments, and wasteway	16·75	19,330,654
Lock No. 3, including excavation	·20	3,832,745
Lock No. 3 to Lock No. 4, including approach walls, embankments, and wasteway	2·77	4,310,580
Lock No. 4, including excavation	·20	5,655,871
Section from Lock No. 4 to San Juan River, including approach walls and embankments	5·30	8,579,431
Conchuda dam, sluices, and machinery	—	4,017,650
Auxiliary wasteway, including sluices, machinery, and approach channels	—	2,045,322
San Juan River section	49·64	23,155,670
Lake section	70·51	7,877,611
Lake Nicaragua to Lock No. 5, including approach wall to lock and receiving basins for the Rio Grande and Chocolata	9·09	19,566,575
Diversion of the Las Lajas	—	199,382
Lock No 5, including excavation	·20	4,913,512
Dam near Buen Retiro	—	125,591
Lock No. 5 to Lock No. 6, including approach walls and wasteway	2·04	3,259,283
Lock No. 6, including excavation	·20	4,368,667
Lock No. 6 to Lock No. 7, including approach walls, embankments, and wasteway	1·83	2,309,710
Diversion of the Rio Grande	—	176,180
Lock No. 7, including excavation	·20	4,709,502
Lock No. 7 to Lock No. 8, including approach walls, embankments, and wasteway	2·43	1,787,496
Diversion of Rio Grande	—	117,580
Lock No. 8, including excavation	·20	4,920,899
Lock No. 8 to Brito harbour, including approach wall	·23	553,476
Brito harbour, entrance, and jetty	·92	1,509,470
Railroad, at 75,000 dols. per mile	—	7,575,000
	183·66	$158,220,052
Engineering, police, sanitation, and general contingencies, 20 per cent.	—	31,644,090
		$189,864,062
Equivalent, with exchange at 4·85, to £39,147,230		

value of the drawings, maps, etc., in the possession of the New Panama Company, and admits that the latter's information in all that relates to the history and completion of the enterprise is unique in the history of great engineering works, it estimates the engineering expense in both cases at the same percentage. Moreover, it allows nothing on account of the difference between 3,300,000 dols. and 2,000,000 dols., the estimated annual cost of maintaining and operating the Nicaragua and Panama Canals, equivalent to a capitalisation, on a 3 per cent. basis, of 43,550,000 dols. In both estimates, also, provision for sanitation (as a capital and not annual charge, be it noted) is made on an identical percentage. The records of the Panama Railroad and Canal are full of warning against such a fatuous proceeding, for they show that the fatal malaria which

some years ago made the isthmus a veritable graveyard was generated by the disturbance of the virgin soil, and gradually decreased with lower excavation. In Nicaragua, for many miles inland from the Gulf coast, in a region where the heaviest excavation is demanded, the soil is largely swamp, the annual rainfall approaches 250 ins., and there is no dry season whatever. It is unnecessary to more fully refer to the comparative merits of the two projects now competing for the favour of the United States. They have been fairly enough discussed in the report of the latest Canal Commission, and I hesitate to believe that the eminently practical American people will commit themselves to a choice, which, in my opinion, can only lead to their own discomfiture and the indefinite postponement of perhaps the greatest gift which engineering science—aided by the vast resources of a mighty nation—can confer upon all the Americas and civilised mankind.

John Geo. Leigh

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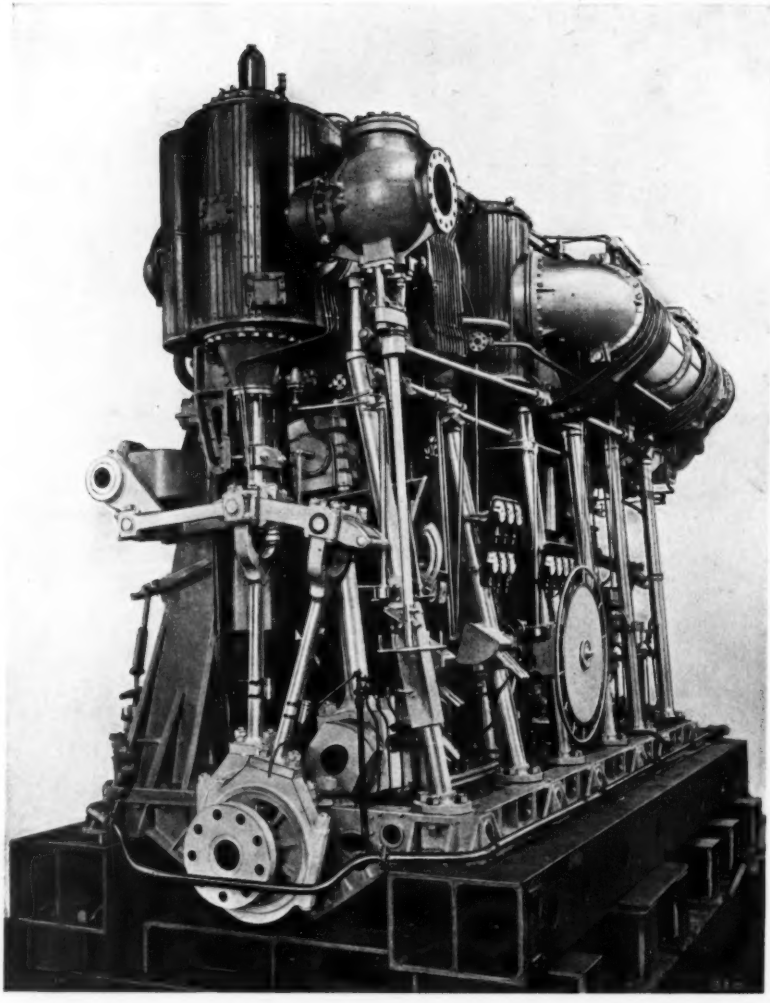


ENGINES OF THE JAPANESE BATTLESHIP
"MIKASA."

See page 355.

New Machinery. Appliances. Structures. & Processes.

The Editor of FEILDEN'S MAGAZINE cordially invites his readers to send him early particulars of New Structures, Machinery, Improvements, etc., for inclusion under this section. FEILDEN'S MAGAZINE undertakes the whole of the cost of illustrations, merely stipulating that proper details, photos, blue prints or tracings are supplied. Where necessary, we will send our editorial representative to inspect and report on any special subject. The Editor, however, reserves to himself the right of accepting or rejecting any matter.

THE JAPANESE BATTLESHIP "MIKASA."

THE *Mikasa*, the latest Japanese battleship, constructed by Messrs. Vickers, Sons & Maxim, is the most powerful of the six battleships built in Great Britain for the Japanese Government. Her general dimensions do not greatly differ from those of modern-type British battleships. Her length is 400 ft., the length over all being 432 ft., the moulded breadth 76 ft., the draught 27·2 ins., and the displacement about 15,200 tons. As regards the area protected by armour the *Mikasa* has unique advantages, effected by an ingenious and efficient arrangement, under which the casemates (instead of being, as heretofore, applied on the scattered method) are concentrated within the central battery, so that there is no unprotected space on the broadside between the casemates. The combined advantage of a complete isolation for each of the 6-in. guns, together with a continuous armour-plated side for the full depth of the ship for a great part of its length is thus secured. The main belt armour in the way of the citadel is 9 ins. thick for 156 ft. of its length, and beyond this 7 ins. in thickness, with an additional 1½-in. nickel steel plate on the slope of the protected deck, the resistance being equal to 9-in. Krupp-Harvey armour for the entire length of the citadel and barbettes. From thence the armour is 5 ins., graduating to 4 ins., an athwartship bulkhead of 6-in. armour being fitted at the after extremity of the waterline belt, for the purpose of affording protection against raking shot. The propelling machinery consists of vertical, triple-expansion, three-cylinder engines (a set of which forms the subject of our presentation plate), the indicated horse-power being 15,000. The cylinders are 31 ins., 50 ins., and 82 ins. in diameter, the piston strokes being 48 ins., and the speed 120 revolutions per minute. Steam is provided by 25 Belleville boilers, with economisers, the heating surface being 37,452 sq. ft., and the grate-area 1,276 sq. ft. The entire machinery weighs 1,355 tons, the horse-power developed reaching the rate of 12 h.p. per ton.

Her first steam trial, to determine coal consumption, required the vessel to run for six hours at four-fifths of her full power, during which period the mean coal consumption was not to exceed 2 lbs. per unit of power per hour. At her full-load draught, with all her guns in position, the mean power on this run was found to be 12,325 i.h.p., the mean consumption working out at 1·53 lb. per indicated horse-power per hour, the speed at this trial being 17·36 knots, a result only equalled within the last two years by one British battleship—H.M.S. *Vengeance*—(also constructed by Messrs. Vickers, Sons & Maxim), the coal consumption in this case being, on an official 30-hours' trial at three-quarter power, 1·51 lb. per indicated horse-power per hour.

Fitted as a flagship the vessel has accommodation for a total of 935, including an admiral and 70 officers. The 1,000 tons of coal she carries on her designed draught gives her a radius of action of about 7,000 sea miles at a speed of 10 knots.

RUSTON PATENT STEAM NAVVY AT THE AVONMOUTH DOCKS.

THE dock extension work at Bristol was ceremoniously inaugurated on March 5th by the Prince of Wales, who was accompanied by the Princess, the city (which is to be elevated to the position of a

MESSRS. RUSTON, PROCTOR AND CO.'S STEAM NAVVY USED FOR CUTTING THE FIRST SOD OF THE AVONMOUTH DOCK, BRISTOL.

port) presenting quite a holiday aspect. At the docks seven or eight thousand ticket-holders witnessed the cutting of the first sod of the new Royal King Edward Dock. After an address had been presented and the reply made, the Prince proceeded to the place where the steam navvy was placed, and, pulling a silver-plated lever, to which an ivory handle was attached, set the engine in motion. The "Ruston Patent Steam Navvy" is the most successful excavating machine of its kind, and has been specially designed by Messrs. Ruston, Proctor & Co., Ltd., Lincoln, who are the sole makers, for making the heavy cuttings for railways, docks, harbours, canals, etc.

It effects an enormous saving in expense over hand labour, apart from the immensely increased speed at which the work can be done.

Over 230 of these navvies have been supplied to various parts of the world, and have proved themselves invaluable in dealing with the large masses of material which require to be displaced on undertakings such as are named above.

As will be seen from the accompanying illustrations the navvy consists of a platform carrying the boiler and engine, on which is arranged a massively built tower, which supports a jib somewhat like a crane. On this jib is centred a swinging beam, carrying at its lower end a bucket armed with cutting teeth, which is dragged forwards and upwards by chains actuated by the engine ; the teeth are thus forced into the opposing bank of earth or broken rock, as the case may be, and then drawn to the top, the bucket filling itself as it travels. The jib is next swung round to bring the bucket over a wagon close by, when the bottom door is opened and the contents allowed to fall out. The jib is then swung back again, and the bucket dropped into position, the door closing at the same time, and a new cut is commenced. With a fair face to work at, the bucket, which holds 2¼ cub. yds., can be filled three times in two minutes.

When working under suitable conditions, it is possible to fill over 500 or more wagons of stiff soil in 10 hours, this being equivalent to upwards of 1,500 cub. yds. per day ; and as an instance of the capacity of the steam navvy, on one occasion 640 wagons were filled in 12 hours by one machine, equal to the extraordinary output of 2,500 cub. yds.

As soon as a wagon is filled it is drawn away, its place being taken by an empty one ; the output of the machine being governed mainly by the rapidity by which it can be supplied with wagons.

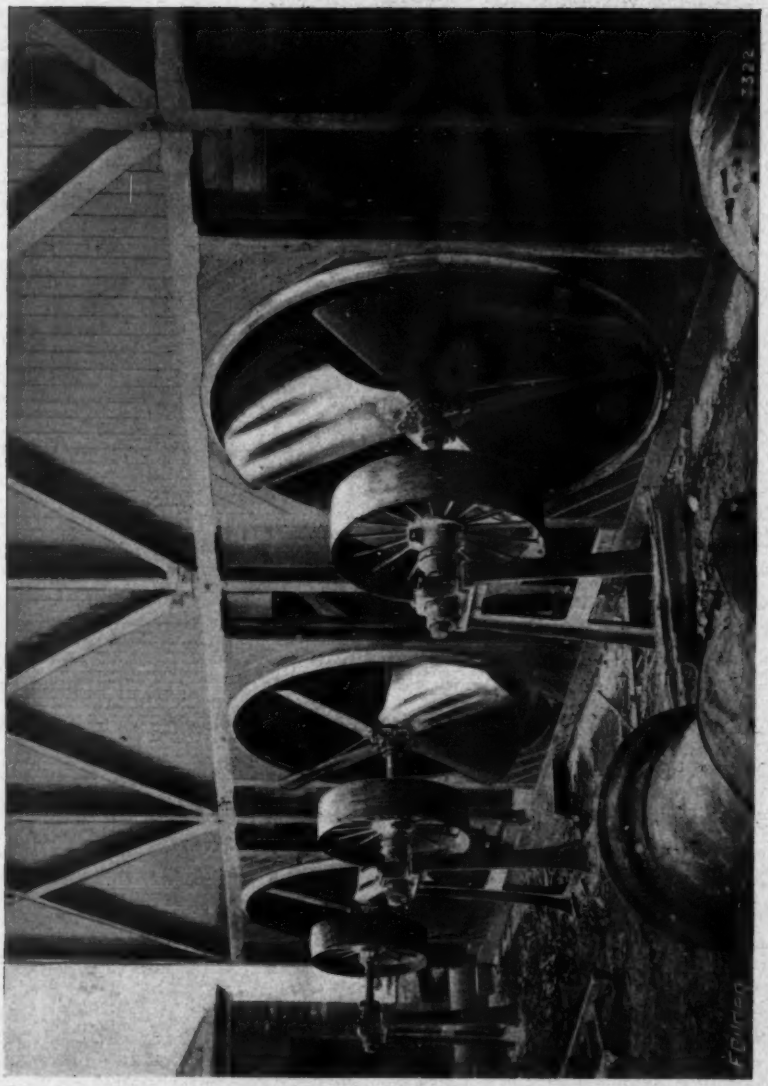
About 70 of these navvies were used on the Manchester Ship Canal, and for the last 25 years nearly every important public work in the Kingdom in which a large amount of excavating has been required, has been accomplished largely by this valuable labour-saving appliance.

AIR-PROPELLING FANS FOR THE BRADFORD CORPORATION.

THESE patent fans have recently been employed in connection with the cooling towers for the Bradford Power Station. The installation consists of eight fans, each being 8 ft. in diameter from tip to tip of blade and mounted in pairs on the same shaft, so as to blow both left and right from either side of the tower. They are driven by belt from an electric motor employed for the purpose, at a speed of 250 revolutions per minute, at which speed each fan is capable of delivering upwards of 120,000 cub. ft. of air per minute, giving for the eight fans the total of 960,000 cub. ft. at a nominal expenditure of 30 h.p. per pair. There is, however, every justification for the expectation that a considerably less expenditure of energy will be actually required in practice. The blades, which are of steel, are secured to the shaft by a very ingenious boss (for which Messrs. Gibbs & Son have obtained Letters Patent), the construction of which renders it impossible for a blade to become detached ; and the method of staying is such that, while most effective in taking the strain to which the blades would be subjected in working, it at the same time affords the least possible obstruction to their effective action. These are among the largest, if not the largest, fans that have yet been employed for this purpose, and are a combination of scientific construction and mechanical skill, of efficiency and simplicity. The efficient action of fans is but little studied in the engineering world, and but few firms have gone so whole-heartedly into the investigation of detail as have John Gibbs & Son, whose efforts have been crowned with such a great degree of success.

NEW WOOD-TURNING MACHINE.

THE illustration on page 360 depicts a new turning machine recently designed by Mr. W. A. Fell, of the Bridge Iron Works, Windermere, for such articles as broom-handles, brushes, billiard cues, shafts, etc., up to 4 ft. 6 ins. long by 2 ins. diameter.



GIBBS' PATENT FANS FOR THE COOLING TOWERS BRADFORD ELECTRIC POWER STATION.

It is a plain gauge-turning machine, and yet more than this, as, whereas the plain gauge lathe has no back tools to form beads, tenons, etc., this machine is provided with two or more back beds, which can be placed in any position on a special planed strip at the back side of machine Moreover, these beds, which hold any shape of tool required, are automatically brought up to the cutting position by the operation of travelling along the front shaping tools. Thus the machine, though not a complete back-knife gauge lathe, possesses many of the advantages which make this machine useful, and at the same time in construction is totally unlike these machines.

Other features of the machine include a special centring arrangement, equally adapted for either long or short work, and worked by the foot, thus leaving both hands of the workman at liberty, a belt fork fitted to the spindle enabling the latter to be stopped at will when altering tools. When it is required to leave the machine for some time the loose pulley does not run on the spindle, so that when the latter is running the pulley is stationary, and when the pulley is running the spindle is stationary. Bearing surfaces have received careful attention, and all the bearings themselves are of phosphor bronze.

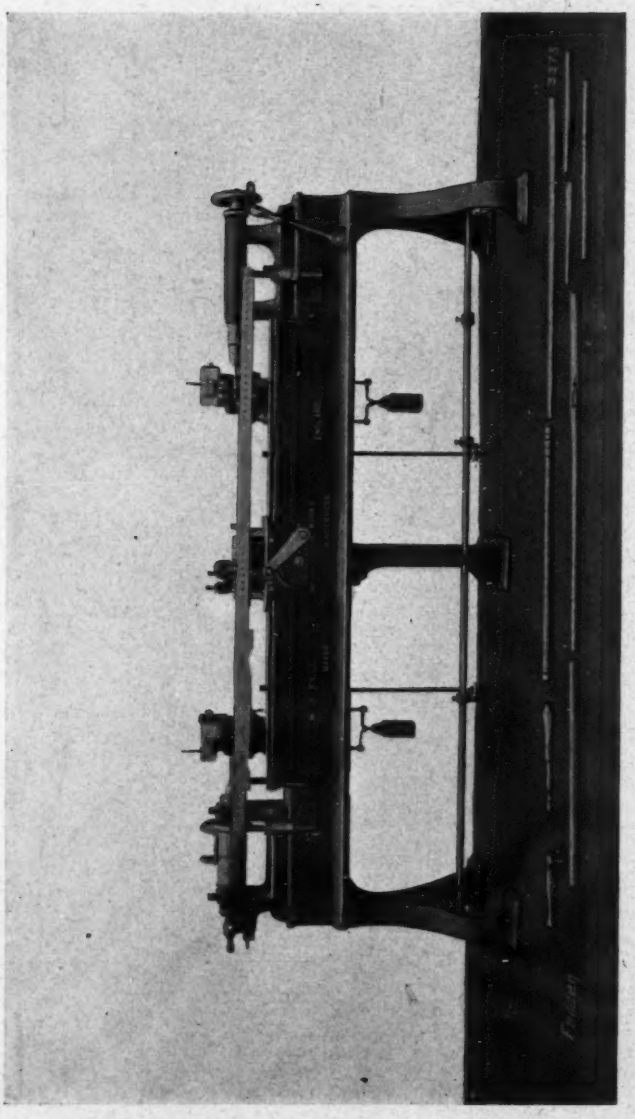
THE BERMUDA FLOATING GRAVING DOCK.

THE great floating dock which was launched from the yard of the builders, Messrs. C. S. Swan & Hunter, Ltd., of Wallsend-on-Tyne, on Saturday the 8th of February, was built to the order of the Lords Commissioners of the Admiralty, and is to be placed in His Majesty's dockyard at Bermuda, where it will replace the old floating dock that has been there since 1869, and which has now become obsolete, not through age, but through the insufficiency of its dimensions. It is, indeed, interesting to make a comparison between the dimensions of the old and the present docks, for they show very clearly the great increase that there has been in the size of the ships of our fleet since the old dock was built; for it, like the present one, was designed with a view to accommodating the largest vessels that were then built or building. The length of the old dock was 381 ft. over all, but to obtain its maximum lifting power gates were fitted which reduced its practical length to 330 ft. Its inside width was 84 ft. between side-walls, and its lifting power was 8,000 tons, which was sufficient for the ships of the *Bellerophon* class, to lift which it was specially designed, although it was capable of bringing the keel out of the water of vessels up to 10,200 tons, the then heaviest ships represented by the long fully-rigged line of battleships *Agincourt* and *Minotaur*. The present dock is 545 ft. long, and having no gates the length of ship it can take is not restricted. Its clear width of entrance between rubbing fenders is 100 ft. Its lifting power up to the pontoon deck level is 15,500 tons; but by utilising the shallow pound this can be increased to 17,500 tons, and the walls are of sufficient height to allow of a vessel drawing 32 ft. to be taken on 3 ft. 6 ins. keel blocks.

The present dock is of the type known as a floating graving dock, the invention of Messrs. Clark & Stanfield, from whose plans it was built. This type, of which many examples already exist, notably the large 18,000-ton dock for the American navy, which has just successfully lifted the battleship *Illinois*, was specially introduced by that firm with a view of producing a structure having a large amount of longitudinal rigidity. The necessity for such rigidity will be apparent when the different types of vessel that the present dock will be called on to lift are remembered. Primarily, it has to lift the line of battleships of 15,000 tons displacement with a length of bearing keel of 343 ft.; but in addition it has to deal with cruisers of the *Terrible* class of about the same displacement, but with 383 ft. of bearing keel; and, lastly, auxiliary cruisers like the *Campania*, weighing some 17,000 tons, with a bearing length of keel of 502 ft. It is evident, therefore, that great longitudinal strength is necessary; since, whilst the dock has to be long enough to deal with the 600-ft. *Campania*, practically the whole displacement of the 545 ft. long pontoons have to be utilised to lift a vessel bearing only on some 384 ft. of their length. Apart from this, the fact that the dock in its voyage out to Bermuda may have to encounter the long rollers of the Atlantic also makes it imperative that a very stiff form of structure should be employed.

Like the original Bermuda dock, the present one is self-docking; that is, it can lift all parts of itself out of water—a most necessary facility in the sub-tropical sea of Bermuda.

The dock itself consists of five portions, comprising three pontoons, which form the main lifting portion of the dock, and two side walls, which, whilst affording a certain amount of lifting power, primarily serve to give the dock stability, and to regulate its descent when the pontoons are submerged.



NEW WOOD-TURNING MACHINE, BY W. A. FELL, WINDERMERE.

The centre pontoon, which is 300 ft. long, is rectangular in shape, but the two terminal pontoons, 120 ft. long, have each only 71 ft. of that length rectangular in shape, the remainder being finished off in the form of a blunt-nosed point or bow. The sides of the rectangular portion of all the pontoons are built up so as to form a broad altar standing 12 ft. above the deck.

The side walls, which come each side of the pontoons, to which they are attached by double fish-plates and tapered pins taking on to the steel lugs built into the structure, both of the wall and pontoon (thus enabling any of the pontoons to be disconnected for the purpose of self-docking), are rectangular structures 435 ft. long by 53 ft. 3 ins. high. From their base up to the altar level their width is 13 ft. 2 ins., but from here they batter back to the engine-deck, where their width is 9 ft. 1 in. Where the boilers occur, however, this engine-deck is built out at the back to form a chamber 12 ft. 6 in. wide. The walls are pierced with two gangway openings, admitting light and air into the interior, and the upper portions, or towers, are cut down at each end, leaving a flat on which the bollards are placed, and the swinging bridges which give access from the top of one wall to that of the other. The ends of the side walls are bevelled off from the back to the same line as that of the pointed portion of the pontoons, thus forming a continuous bowline for the purpose of facilitating the towing.

The pontoons of the dock are divided into 40 pumping divisions, of which 32 are absolutely watertight and distinct. The side walls have each eight watertight divisions. All these 56 divisions are provided with a separate pipe, each governed by a separate valve. All the pipes in the starboard half of the dock are led directly into the main drain in the starboard wall, and those on the port side into the port wall. These drains are continuous over the whole length of the walls, and the four 18-in. centrifugal pumps in each wall are seated directly on them, so that any one pump can empty all the compartments of its half of the dock. Furthermore, the central bulkhead dividing the dock into the two halves is not entirely watertight, but small drainage or leakage holes are left in it, so that even in the event of a complete breakdown of the whole of the plant, the other half could still slowly empty the whole dock.

A separate condensing compound engine driving directly on to the pump-shaft is provided for each pump, and a separate return tube marine boiler for each pair of engines. The steam pipes are, however, so arranged that either engine can take its steam from either boiler.

Each boiler, engine, and pump is therefore duplicated in each wall, and further, each wall duplicates the other, so that if only one boiler, engine, and pump remain available the dock can still be lifted.

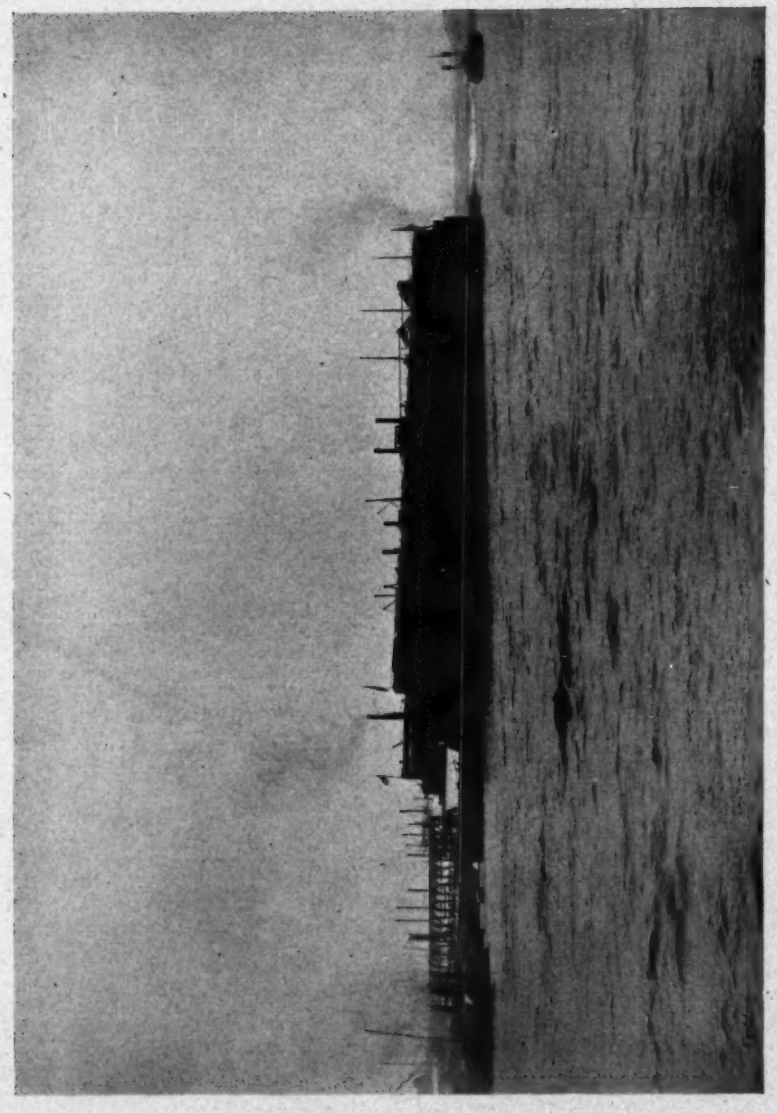
Although the dock is divided into 56 divisions, each with its own regulating valve, the working of the whole dock is all done from a central position on the top of each tower. There are grouped in the valve-house hand wheels, which by means of rods and cranks are connected to the different valves. Each valve-house is in direct communication with the engine-rooms, so that the man in charge can, without quitting his station, manipulate every valve, either water or steam, required for the manœuvring of the dock. Each valve is further fitted with an indicator, which shows on top of the valve-house exactly which valves are open and which shut, so that the dock-master can see from any conning position he may take up exactly how his dock is being regulated on both sides.

Special provision has been made on the broad altars for the support of the armour belt of battleships, a stiff channel running along on top of them into which the heel of the vertical shores can be stepped, whilst similar channels along the face of the altars receive the raking shores that support the bilges, the shape of the dock at this part resembling fairly closely the stone steps or altars of an ordinary masonry dock.

The dock is provided with the usual fittings in the way of strong bollards on the low walls and timber-heads on the top deck; and, for warping the vessel into place, six powerful vertical steam capstans are provided with sheaves or fairleads on the edge of the top deck.

An electric light installation, with its own generating plant, is provided in one wall for lighting all the interior compartments of the dock; and in addition twelve arc lamps are carried on gallows on top of the towers, which light up when required the whole dock and ship, whilst further mains are led along the dock sides, from which hand-lamps may be taken off to light up any particular spot where special work is being carried on.

A very useful fitting for handling weights, either on the dock or ship, will be found in the travelling and swinging electric cranes which run along the whole length of each wall. They are of 5 tons lifting power, with a jib radius of 36 ft. and a lift of 35 ft. above the top deck. They are electrically driven by means of a separate generating plant placed in the towers, but this plant is so



FLOATING GRAVING DOCK FOR BERMUDA. BUILT BY MESSRS. C. S. SWAN AND HUNTER, WALLSEND-ON-TYNE.

arranged with the electric lighting plant that they can be used alternatively, or together, for either lighting or working the cranes. These auxiliary installations, whilst usually taking their steam from the dock's boilers, are each provided with their own boilers, making them independent therefore of the main pumping installation.

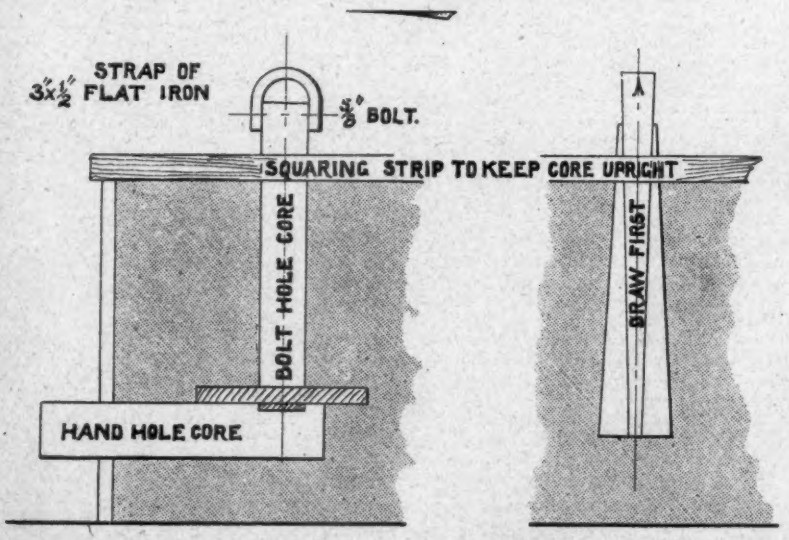
A complete drainage service, communicating with all the dock compartments and capable of emptying them completely, is installed in each wall; and by the alteration of a coupling this service can also be used as a washing-down service, by means of which the outside of the ships on the dock can be washed down or their inside tanks tested with water.

The bottom of the pontoon is protected by a series of bilge-keels of teak, as it is possible that at low-water the dock may, to a certain extent, sit upon the rough, coral bottom of the harbour where she will be moored.

The top decks of the walls are planked with teak, with a waterway all round; and arrangements are made, in view of the scarcity of fresh water at Bermuda, for catching and running into the reserve water tanks inside the walls all rain water falling on these decks.

The pumping machinery of the dock has been provided and erected by the Wallsend Slipway and Engineering Company, Ltd., the engines and pumps being by W. H. Allen, Son & Co., Ltd., of Bedford. The electric-lighting installation, the electric travelling cranes, and the generating plant for the same are made by Clarke, Chapman & Co., Ltd., who also fitted the steam capstans on the top deck.

The dock will remain in the Tyne until the fittings are completed, and in the early spring she will be towed to Chatham, where her trials will take place, consisting in the lifting of a first-class line-of-battleship and the self-docking of her pontoons. After this she will start on her long voyage to Bermuda.



Coring for Cotter Bolt

Coring for Rag Bolt

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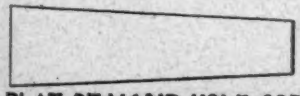


PLAN OF HAND HOLE CORE
—SHOWING TAPER—

CONCRETE FOUNDATIONS. (SEE PAGE 366.)

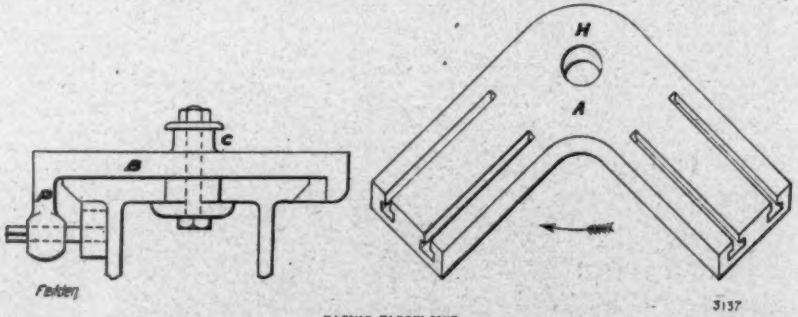
WORKSHOP PRACTICE

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

❀ ❀ ❀

Facing Elbow Pipes.—In facing different sizes of elbow pipes, some little difficulty is experienced at times in getting the flanges at right angles to each other in the same vertical plane, consequent upon another setting being necessary to face the second flange. The following arrangement, shown by Figs. 1, 2, etc., provides a method applicable to any ordinary elbow, whether the flanges are at right angles or otherwise. A cast-iron base-plate *B*, Fig. 1, a little wider than the lathe bed, is provided with vees on the underside to slide on the surface of the lathe bed. To this plate a bracket *P* is cast or bolted, to support a short shaft with squared end for traversing handle, and fixed pinion engaging in rack bolted on front of lathe bed. This provides a means for moving the plate to the required position. A boss at *C* is used as a pivot on which an an angle plate *A*, Fig. 2, with hole at *H*, is free to revolve. A bolt passing through the boss *C*, and fixed into a clamp plate on the under side of the gantry, securely holds both plates in position. Slots for T-headed bolts are cored at right angles in the plate to which is attached a fixing, carrying top and bottom V'd blocks for supporting the elbow casting. For lightness, and in order to accommodate a small diameter of casting, the bottom V blocks are cored out, which allows the top block to slide down to the required position within the space. A series of T-headed slots at the ends of the bottom V-block allow for the easy adjustment of the clamping down bolts passing through the flange of the top block. The elbow casting is clamped in position, and the flanges faced with a tool fixed in a slide bolted to the face-plate of the lathe, the slide being moved forward at each revolution by a star wheel striking against a stop fixed on the lathe bed. A stud is inserted in the bottom plate, fitting slotted lugs in the top one. This locates the swivelling plate *A* for the first cut, and by moving round in the direction of the arrow, the second flange is brought into position for the next cut. By this method the pipe flanges are quickly and accurately faced at a minimum of cost, and a great saving of time in re-setting and testing.

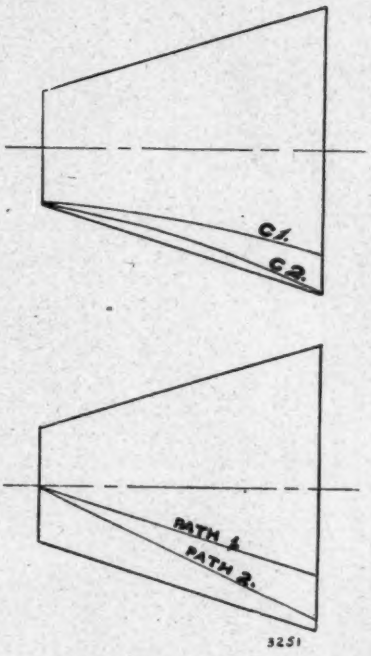
(£1 1s.) SETH FORTUNE.



FACING ELBOW-PIPE.

Taper Turning.—In the turning of taper bushes, etc., it is generally understood that to form a correct cone of the same angle that the compound-rest is set, that the tool must be set exactly on a level with the axis of the cone, but it is not always known why this is the case. The explanation is briefly as follows. Suppose we have a perfect cone fixed between the lathe centres, and that the compound-rest is also set at the same angle. Then, if the tool be placed exactly level with the lathe centres, and traversed along the cone, it will be found to just touch all the way along. Now suppose the tool to be set *above* the centre, taking an exaggerated case, it will be found that the tool on being traversed along will only touch at, or near, the middle. As the tool always travels in a horizontal plane, we may assume that the tool is set to just mark the small end of the cone, also that the tool be traversed along until it reaches the large end, or base, of the cone, and there also make a mark, the tool would, of course, have travelled horizontally. The straight line between the points would lie in a horizontal plane, parallel to the plane in which the axis of the cone lies. Now, taking the two extreme points between which the tool was assumed to have been moved, the tool would have travelled in a straight line between these two points; but, try to place a straight-edge between them and it will be found that a convex surface lies between them. Therefore, if the tool had really been traversed along in the assumed position, it would have taken more off in the middle, and would have made the surface hollow. It will be obvious that exactly the same will take place if the tool is placed *below* the centre. The diagrams show the paths set and the surfaces produced by the tools arranged as follows: (1st) the tool is set *below* the lathe centres a distance equal to one-half the diameter of the cone at the small end, and the swivel slide is set at the same angle as the cone, with the tool touching at the small end. The line *C* 1 represents the form that the tool would turn if traversed in that position; in the second the swivel slide is set so that the tool will touch the cone at both, and the line *C* 2 shows the form that would then be turned. From these considerations it is evident that the cutting edge of the tool must be always in the same plane as the axis of the cone; with any other position the surfaces of external cones will be hollow and internal ones round.

WILFRED L. SONES.



TAPER TURNING.

Checking Triangular Spars.—Some time ago a considerable number of gratings with triangular spars had to be made, and, as there was no saw to cut the spars to the required length, the following apparatus was devised for holding them during the checking and cutting-off operations, which were carried out on a shaping machine. The spars were of the shape shown in Fig. 1, this being a triangular bar checked down at each end about $\frac{5}{32}$ in., and a sufficient distance along to allow them to pass through the grating with $\frac{1}{16}$ in. over for riveting. Two bars of iron were first planed up to the same thickness and vees cut across them to fit the spars, Fig. 2, the vees being so spaced that the tops of the spars lay close to one another when in place, and projected $\frac{1}{8}$ in. above the slips to allow of the check being cut. Along one of the slips a groove was cut to the bottom of the vees to give clearance for the parting tool *A*, Fig. 2. Holes were then drilled through the ends of the slips to fit the slots in the table *B*, Fig. 2 The slips were next bolted down square to the machine, a sufficient distance apart to allow for a gland to hold down the bars, Fig. 3. For this purpose a heavy slip

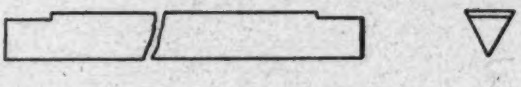


FIG. 1.

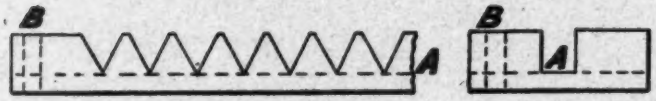


FIG. 2.

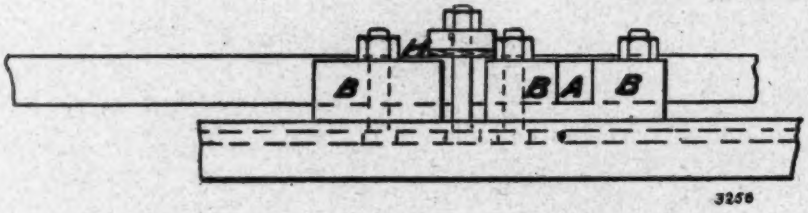


FIG. 3.

CHECKING TRIANGULAR SPARS.

with suitable holes was used, a thin slip of hardwood *H*, being placed between it and the bars to allow for varia ions in size of the rough bars. A plate was used to place the finished ends of the spars against, to ensure all being the same length, the bars being first checked on one end and faced up, pushed against the plate, and the other end and the end of the next spar checked down and parted off at the same time. The checks were made $\frac{1}{16}$ inch smaller than the punched holes to allow for inequalities in black bar sizes. WILLIAM BURNS, Jun.

Concrete Foundations for Engines, etc.—In making concrete foundations for machinery, the first procedure is to determine the size of the bed. In length and breadth we are governed by the machine to go on it, and the thickness is the variable quantity. Unless it is very well supported a concrete bed should never be less in thickness than one-tenth its length, or if the bed is less than 10 ft. long, 12 ins. thick should be the minimum. In the case of a steam or gas engine the bulk may be reckoned as 5 cub. ft. per i.h.p. for small engines, and about 3 cub. ft. for engines over 50 i.h.p. The floor of the shop or engine room is first levelled, and if soft, gravel or broken bricks rammed over it. If a flush bed is to be made the excavation should be 2 ft. or 3 ft. bigger every way than the bed (except in depth). The "frame" is then made—a bottomless box of the required internal dimensions—and laid in place to commence filling, the frame being secured by spikes driven round it.

The best mixture for concrete is two shovelfuls of sharp, *clean* sand, one of Portland cement, to five of broken brick or stone; passed through 1½-in. meshes: gravel, shingle, Thames ballast, or coke breeze should never be used for foundation work. The concrete should be well mixed and well wetted before throwing into the frame, and as the latter is filled the concrete should be well rammed for consolidation. When about 4 ins. to 6 ins. of concrete has been put into the frame the bolt hole cores are put in. These cores are of wood, either well oiled or soaked in water. If put in dry they will swell up and stick. The sketches show method of coring for either rag or cotter bolts. The frame being filled should be given a night to set, and then "floated" off with grouting composed of 2 of sand to 1 of cement and the same bulk of water. It should be liquid enough to flow freely, and poured over the concrete to make a smooth facing. After the "floating" has set, the frame should be knocked apart and the foundation allowed to dry before drawing

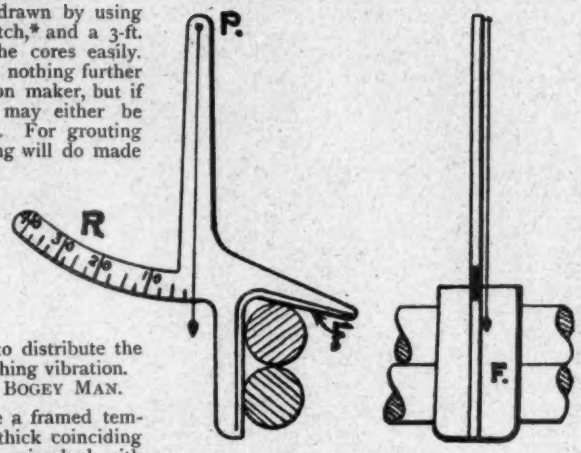
the cores. The cores are drawn by using a strap of W.I., as per sketch,* and a 3-ft. pinch bar will bring out the cores easily. In the case of cotter bolts nothing further is required of the foundation maker, but if rag bolts are used they may either be "leaded" or "grouted" in. For grouting the mixture used for floating will do made stiffer, but not so stiff that it will not flow. If good cement is used the grouting will set in 8 to 12 hours.

It is a common practice to place 1-in. timber between the cast-iron bedplate and the concrete. This not only helps to distribute the weight but assists in diminishing vibration.

THE BOGEY MAN.

[It is also usual to make a framed template of timber about ½ in. thick coinciding with the underside of the engine bed, with the bolt holes cut through, in order to locate the cores in exact position in the concrete. —ED.]

* See page 363

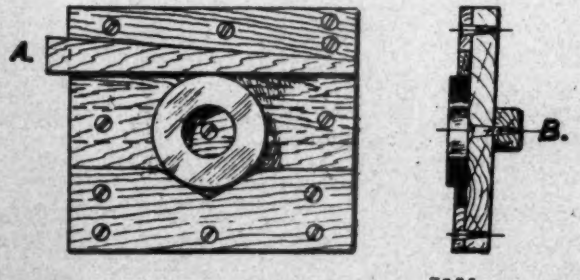


ADJUSTING METAL ROLLERS.

Adjusting Metal Rollers.—In many operations where thin sheets of material have to be passed between long rollers, it is absolutely necessary that the axes of the rollers shall be parallel, and it is often required that the top roller shall not be vertical with the bottom, but at some definite angle. The use of straight-edges and angle-plates is unsatisfactory, and the gauge is a much more reliable test. It is preferably cast in brass, the side flanges *F* giving a better bearing on the rollers, or it may be made of sheet metal one-eighth or one-tenth of an inch thick. The face touching the rollers is made parallel to the centre line of the vertical stem, which is provided with a line and small plumb-bob. The radial arm *R* is graduated from 0 to 40 degs., or further if required. By placing the gauge on each end of the rollers and setting until the plumb-line is at the same mark, the rollers are known to be quite parallel, and by setting to any angle on the scale the inclination of the rollers is known to be correct. If the rollers are not of equal diameter, a piece of packing may be inserted between the gauge and the smaller one, or allowance made when taking the reading. The size of the gauge may be made convenient to the range of the work.

J. H.

[We think a pointer, free to swing on a pivot at *P*, would be an improvement on the line.—ED.]



FACING UP THIN WASHERS.

Facing up Thin Washers.—In most fitting shops the vices, being of the ordinary leg type, are unsuitable for holding thin washers which are very easily buckled. A device for holding such, which have to be carefully filed and faced, is shown in sketch.

A piece of hard wood has two other pieces of hard wood, made thinner than the washers to be faced, screwed on it in the manner

shown. A wedge of the same thickness fits in at *A*. The washer is placed in position shown, and held firm by the wedge. The piece of wood *B* on the back of the board is gripped firmly in the vice jaws.

NORMAN S. RICHARDSON.

The Practical Construction of the Marine Propeller.—The principle of the propeller is that of a screw having an abnormal width of thread of extremely coarse pitch wound round a comparatively small cylinder. In the helix of long axial pitch (Fig. 1), the analogy will be at once apparent, but with the exception that only a portion of the thread is used, and these portions set on the same plane correspond to the number of blades composing the propeller and connected by a boss through which the shaft passes.

The varying forms of propellers are legion, and no attempt could be made to enumerate them, so that only those in general use are given. In order to make the subject as clear as possible, it is necessary to define the terms as follows:—The *pitch* of a screw is the distance from the centre of one convolution to the centre of the next as *A* to *B* on Fig. 1. The extreme point of the blade is designated the *tip*, and the bottom part joining on the boss is called the *neck* or *root*. The *radial length* is the distance from the periphery of the boss to the tip of the blade. The *driving surface* is the after or flat surface of the blade. The edge first entering the water is named the *leading edge*, and the opposite one the *following edge*.

A *true* screw is one equal at every point on the blade, or when the angle taken at any part converges to the same centre. A pitch varying *radially* is when the pitch gradually increases from the root to tip. A screw is said to vary *longitudinally*, when the pitch of the leading edge is *less* than that of the following edge. Propellers with pitches varying in both directions, and those having the face set back at an angle, or as it is termed "going astern," present some little difficulty at times to both pattern-maker and moulder, as in the case of the former they necessitate the making of more complicated tackle, and a combination of the methods of setting out the angles, whilst the moulder has to make special provision in other directions. The drawing for a propeller as supplied by the draughtsman usually represents the end and side elevations with all the figured dimensions.

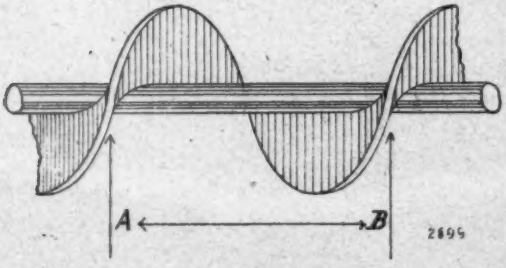


FIG. 1.

The end view gives the form of blade and the developed surface, whilst the side elevation shows in section the thickness of the blade, with the angles of the face at neck and tip, as Fig. 2. These angles are the chief feature, as representing, with the diameter, the starting points of the pattern. The first example given at Fig. 3 illustrates the method of constructing a full pattern of a three-bladed left-hand screw, as shown in the preceding figure. A number of pieces of timber are first planed up to a parallel width and thickness, the end of each piece being cut equal from the centre to an angle of 60°, making the included angle of 120°, as shown.

The angle at the tip being previously set out on a board, the pattern-maker can at once determine the width of timber required and ascertain the amount of lead or distance that one piece must be set in front of the previous one. The pieces, after being cut, should have the angles jointed together, a little chalk rubbed on the ends preventing the too rapid absorption of the glue. After the joints are set the triangles should be trued up and jointed on the flat.

This is best accomplished on a level building board, a few small "dogs" being used to nip up the joints as each layer is built.

After the building is completed and the joints thoroughly set, the flat face of the blade is finished to the correct angles, by paring away the overlapping parts of the timber down to the lines of intersection, thereby forming the driving surface of the screw.

A centre line is then scribed on this surface by means of a scribing block, though sometimes the thicknesses of timber can be so disposed that a joint line may represent the centre line.

The blade is then worked to the sections as indicated on the drawing by means of templets made out of thin timber, and sometimes —though not necessarily—a few pegs of varying lengths and coinciding with the thickness of the

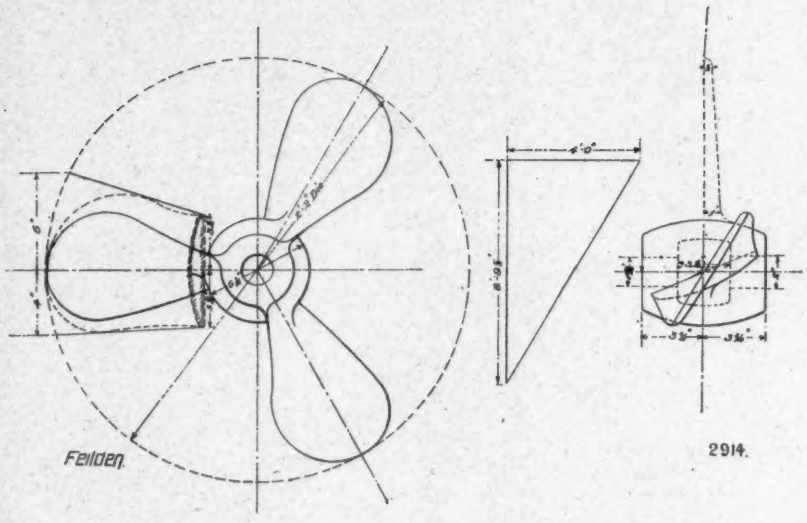


FIG. 2.

blade at the centre line are driven in the pattern as a guide when roughing out the back of the blade. On the flat or driving side of the screw, the developed surface of the blade is marked out, and the pattern-maker then proceeds to cut away the superfluous timber and finishing the neck into the boss by easy curves, the boss being usually in the form of a flattened sphere or barrel shape. Two and four bladed screws are built up in a similar manner but without the radial joints, the first being formed with parallel pieces of timber set in advance of each other, whilst the second is built up with pieces half lapped in the centre at right angles.

We now pass from the construction of the full pattern to that of a propeller formed with an equipment which at first sight appears to bear very little analogy to the casting produced. This method is known as loam-moulding, the mould being of a composite character, the outside and body consisting of iron plates supporting bricks built up to a rough outline, and bonded with a mortar made of clay-wash and black sand. The surfaces of the mould on which the metal impinges is formed of a plastic material, composed of red sand and other ingredients ground together, and used about the same consistency as building mortar. It is struck up or swept to the required form by loam-boards and strickles of different shapes, the contour coinciding—though not always—with the surface of the casting. The operation of making a full pattern is confined to

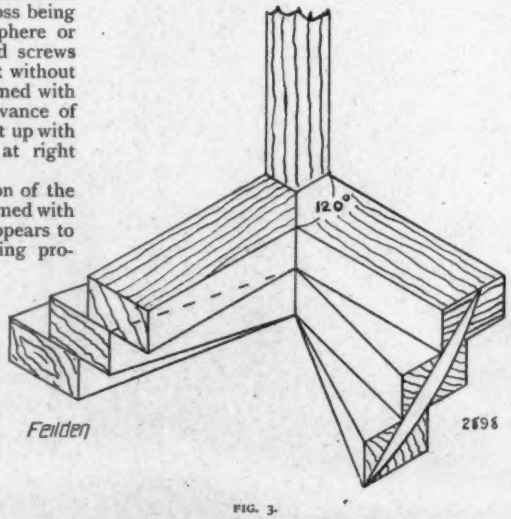


FIG. 3.

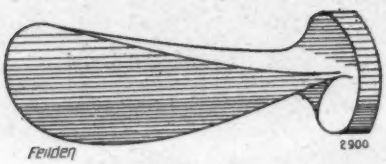


FIG. 4.

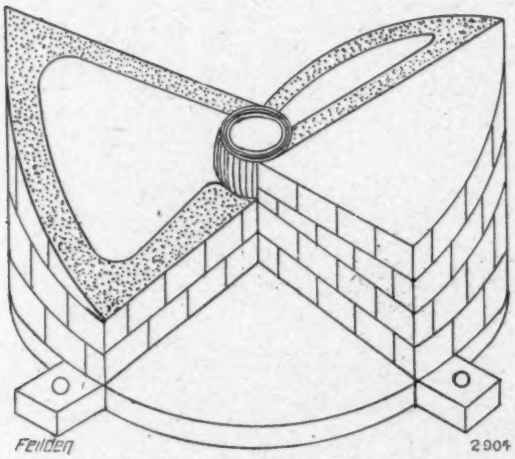


FIG. 5.

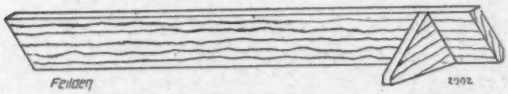


FIG. 7.

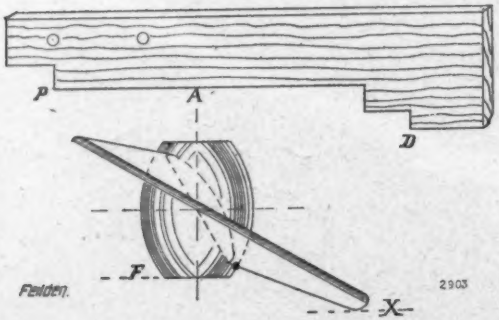


FIG. 6.

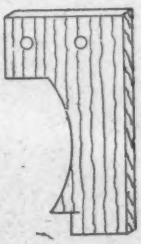


FIG. 8.

the smaller diameter of screws, or such as the one shown at Fig. 2; but the making of the larger ones in this manner would not be permissible, as the loam moulding is a readier and much less expensive method. The modern propeller, as used on the large ocean liners, usually consists of four blades bolted on a large boss recessed at equal distances round the circumference. The blades invariably terminate at the neck in a circular flange, making, when bolted on the surfaces of a box form of boss, or as Fig. 4, the complement of a spherical boss to which they are attached.

Before describing the construction of the blade for this form of screw, the solid type—usually of cast-iron—as fitted to an ordinary cargo steamer, is taken, and Fig. 5 shows a perspective view of the mould for a two-bladed propeller, with the top part of the mould removed, the inclined plane representing the face of one blade, and the outline thereon the contour of the same. The necessary preparations for a mould of this kind are as follows:—A circular iron plate a couple of inches thick, and about 2 ft. larger in diameter, with four projecting lugs, is cast in open sand, with a circular hole through the centre to admit the loam spindle, to which is attached the boards. These, Figs. 6 and 7, are made out of 1½-in. timber, the latter having an angled block screwed on one end to form a better bearing surface when sweeping down the inclined plane of the tip race. A peg, or screw with the head filed off, is fixed in the other end as a further guide. Sprigs driven in the edge of the board and filed to a point describe lines on the loam surface on which the section pieces are set.

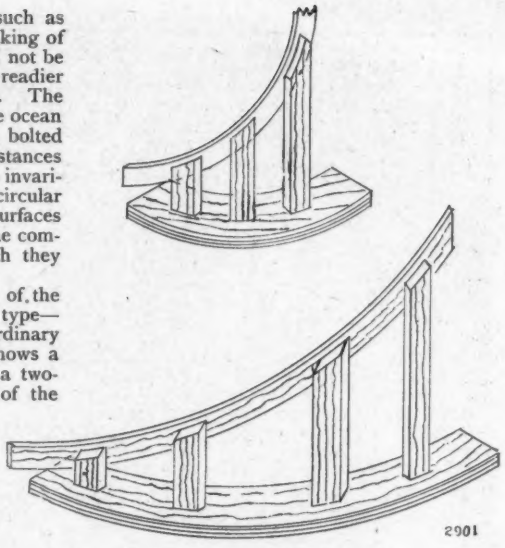


FIG. 9.

One other, as Fig. 8, is required for forming the boss. Particular attention must be given to the making of the first board, Fig. 6, the set-offs representing different planes on the surface of the loam.

At Fig. 6, is shown the loam board or strickle, such as would be required for the propeller shown in end elevation below. The line *A* on the board should be about 1½ in. below the face of the boss and the distance from the centre of spindle to point *P* just clear of the boss at its largest diameter. The distance *D* must agree with the inside radius of the segment forming the base of the tip race, while the overall length is some few inches over the plate diameter. The most important point to notice in making this board, is that the distance from base of boss *F* to the lowest plane formed by the strickle, will be low enough to clear the extreme point of the blade at *X*. The neck and tip races, Fig. 9, each consists of a segmental piece of timber forming a base to which are attached vertical pieces of timber of varying heights, corresponding to the required incline, a continuous edge being formed by a strip of hard wood about a couple of inches wide and a quarter-inch thick.

These "races" represent respectively the incline of the driving surface of the blade, that of the neck being correct, whilst that of the tip shows a more acute angle, consequent upon the greater distance from the centre of the screw to the edge of the race, than the radius of the blade, as a suitable amount of margin is necessary to form the outside of the mould.

(To be concluded.)

W. H. W.

INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION

FROM ALL SOURCES.

Electrical Traction on Railways. — The Paper read by W. M. Mordey and B. M. Jenkin, M. Inst. C.E., before the I.C.E. In view of the questions arising out of the recent Inner Circle arbitration as to the practicability of the general application of electrical working to railway systems, the authors considered the present time a suitable one for a general review of the various electrical systems applied to or proposed for railway working. Short and busy railways were now being successfully worked by electricity, and longer lines were calling for attention. As the distinction between railways and tramways was rather arbitrary, much of the Paper was to be taken as referring to tramway work as well as to railway work. The principal features of existing systems were classified and described under three heads, viz. :— (1) Direct-current methods; (2) composite direct- and alternate-current methods; and (3) alternate-current methods. It was shown that, in the first-named class, viz. purely direct-current methods, the principal alternative to the simple 500-volt two-wire system was the three-wire system in various modifications, which were explained. This was followed by a description and diagram of the method adopted on the City and South London Railway, which was the only important example in actual practice of a purely direct-current system using other than the simple 500-volt arrangement. This system was a three-wire distribution combined with feeders supplied at 2,000 volts. The composite method—that used on the Central London Railway, was next described, in which high-tension three-phase alternate-current transmission was combined with step-down transformers and rotary converters, to give direct current to the railway. The existing alternate-current methods were all described under three-phase working, and it was shown that on the Continent there was a decided tendency to work out the more difficult traction problems by the use of three-phase alternate currents, not only for transmission, but also for working the trains themselves. A Table was given containing particulars of the principal three-phase electric railways. The authors then proceeded to discuss the comparative advantages and disadvantages of these three classes of methods, giving curves to illustrate the efficiencies of the sub-stations according to the methods adopted; and a Table showing corresponding costs of the plant, etc., required. The advantage to the direct-current and composite methods of their easy use of accumulators was pointed out, but the possibility of also using these on alternate-current systems was considered. The systems were also compared in their relations to number of conductors, speed, effect of variation of voltage and relative complexity of the sub-stations. The Paper next considered the starting-torque of single-phase alternate-current motors, with illustrative diagrams of curves, after which consideration was given to the increased electrical resistance of the rails with alternate currents, according to the periodicity. Some tests made by Mr. Blathy on this matter were communicated by the authors. The effect of these results on the use of alternate currents was considered rather fully, the limitations imposed being pointed out, and conclusions being drawn as to the probable advantage of using copper conductors in place of the rails. Attention was drawn to the choice of periodicity as affected by lighting, rail-resistance and effects. A short section followed on lighting. The return of energy to the line when running down gradients and when stopping the train was dealt with. It was pointed out that efforts to do this with direct currents had not had any success, but with alternate-currents the problem was much easier; in fact, the method was used on most of the existing alternate-current lines, not so much with the object of economising energy, as for the sake of obtaining a very convenient brake. The importance of variable-ratio control was next considered, the special need for such a process being shown by the fact that with the present methods, direct-current or alternate-current, the maximum losses of power and the maximum output of the generating-station occurred when the power developed at the train was least. The authors summed up under the following twelve heads the requirements that should be met in any general system of electrical railway working: (1) extra high-pressure for feeding sub-stations; (2) avoidance of moving machinery in the sub-stations; (3) on longer lines a high-pressure distribution to the trains; making necessary, (4) overhead conductors; (5) easy extension of distributing-system; (6) ability to supply trains having different systems of motors and control; (7) high acceleration when starting; (8) the return of energy on gradients, or when stopping; (9) possibility of using different speeds; (10) a variable-ratio arrangement for starting, for speed regulation, and for returning energy; (11) possibility of using motors on a locomotive or distributed on the train; (12) the train-equipment and control to

admit of extension and modification to work on other systems. The first six of these referred to the distribution of power, and the last six to the equipment of the trains themselves. The first five led to single-phase alternate-current working as the only method that fulfilled all the conditions. The authors accordingly proceeded to discuss whether any system of utilising single-phase current was possible; and they described in considerable detail a method originally proposed by Mr. Ward Leonard. In this system a single-phase motor on the train would drive a direct-current dynamo provided with means for separately exciting it, and for varying its e.m.f. over any desired range. The current from this dynamo would be taken to a separately excited direct-current motor. By this means there would be provided a most flexible variable-ratio transformation; and the advantages of such a system were pointed out. It was then shown that such a system satisfactorily met the other seven requirements laid down, and offered at least a practicable solution of the problem of a comprehensive general system of electric traction for railways.

British *versus* American Patent Law Practice and Engineering Inventions.—It was pointed out (by Mr. Benjamin H. Thwaite, in his recent paper read before the S. C. E.) that during the nineteenth century and up to the seventies British engineering was supreme, and that the railway, gas, sewage, and other undertakings—the productions of British inventors of the early part of the Victorian era — were almost exclusively designed and constructed by British engineers and with British constructional machinery. At the end of the last century the marvellous progress of the Americans displaced England's industrial supremacy, especially in metallurgical and engineering developments. Much of the engineering work that was once controlled by British engineers is now being carried out by American engineers. The author showed that the progress of American manufacturing and engineering industry was directly due to the encouragement held out to inventors by the successive United States Governments from the time of Washington. The encouragement given to American inventors by the Act of 1861 had rewarded Americans with a wave of unequalled prosperity. The author pointed out that the British policy in reference to the inventor was quite different from that of the United States, and that whereas the British inventor might obtain a British patent, which was merely a registration of date and the printed disclosure of the invention, and for which, for a period of validity of 14 years, he had to pay no less than £99, the American inventor was given for the sum of £3 odd, the benefit of an unprejudiced examination and investigation by technical experts. If the patent passed successfully through that ordeal the inventor had to pay an additional fee of £4, for which he secured, without any further payment whatsoever, the right to the patent for a period of seventeen years from the date of application. The chances that an American patent would pass safely through a law contest were 74 to 100, whereas the chances of the British patent being found valid were only 58 to 100. The author then showed that whereas in seven American States, noted for the inventive characteristics of their people, the capital value *per capita* equalled 682 dols.; in seven other States, each having a population of low inventive capacities, the capital value *per capita* only equalled 176 dols. The author observed that seven-eighths of the many hundreds of millions of dollars of capital invested in American manufacturing industries were applied to the manufacture of patented articles, products, or machinery. To demonstrate the deadly effect of the yearly taxation of the British patent system, the author stated that of the 138,517 British patents applied for during the last five years some 104,000 became void in the fifth or sixth year from the date of the application, and the British Government would have drawn in fees from those abandoned patents nearly three-quarters of a million sterling. The author showed that in ten recent years the profit surplus earned by the British Patent Department was over one million sterling; the American Patent Department earned a profit of £275,000. The author referred to the economic policy of the United States manufacturers, which explained the reason why comparatively modern plant was often replaced by new appliances which earned increased profits by their improved efficiency. He recommended the adoption of the American patent system, which policy would stimulate the inventive characteristics of the British race. He referred to the 1901 Committee appointed by the present Government to inquire into the British patent system and give their main conclusions and opinions, which were strongly in favour of stringent legislative revision; and he called attention to the recent introduction into the House of Commons, by the Government, of a Bill having that object. In his final remarks the author observed that so long as England had the trade and industry of the world practically to herself she could handicap the representatives of her industries with almost intolerable burdens with impunity, but those burdens must now be removed, or England's champions would be compelled to cry "peccavi" and retire discomfited from the arena.

American *versus* English Machinery in China. — In connection with the frequent announcements going the rounds of the newspaper press, anent the capture of machinery orders by American firms in markets which the British manufacturer had previously dominated (certain identical reports being frequently repeated *ad nauseam* in the same journals in different forms) it is refreshing to get a glimpse of the other side of the question, and to find that an old-established firm of English flour mill engineers have just secured the contract for the supply and erection of a large flour mill on the most modern system in North China. More than one firm of American makers were competing for the work, and, although they claimed to produce by their process better qualities and higher percentages of flour, the English firm in question was able to satisfy the buyers as to the

superiority of their machinery, and its ability to produce qualities and percentages equal, or superior to, the Americans. This English house takes the contract at a price below any of the American houses, and has undertaken to ship the whole plant in 10 weeks from date of acceptance of order. The firm in question (Messrs. E. R. & F. Turner, Ltd., of Ipswich), some months since shipped a similar complete flour mill to China, the order for which was also secured in competition with America.

Utilisation of Peat Fibre.—It is reported in *Kuhlow's German Trade Review* that at Dusseldorf has been discovered a means of using peat fibre. It is stated that a fibre has been produced capable of being spun, which is absorbent, and which can be bleached and dyed. The vegetable fibres were first isolated, and treated with acids and alkalis, the result being a peat wool consisting of nearly pure cellulose. This turf wool is soft, elastic, and capable of being spun in the same way as sheep's wool. With the addition of cotton or sheep's wool, yarn can be spun which is useful for various clothing fabrics. The felt manufacturer uses it in the production of peat-felt hats. If the inventor is successful in reducing this peat yarn to a still finer thread, it will, perhaps, find great use in hosiery manufacture, for which, as it is a bad conductor of heat, is absorbent, and cheap, it is especially suitable.

Dry Dock Construction at St. John, N.B.—According to *Engineering News* (New York), it is proposed to construct a new dry dock at St. John, N.B. A committee appointed to visit American docks and recommend a plan has reported as follows: The dock to be built of wood, with concrete and granite entrance, with pumps that would empty the dock in 80 minutes. The dimensions would be: length on keel-blocks, 665 ft., including a 15-ft. recess at head of dock for the bows of ships; width of entrance at bottom, 75 ft.; at top, 90 ft.; width of dock basin at coping, 140 ft.; width of dock on floor, 75 ft., and 83 ft. at top of keel-blocks; depth of water over floor at extreme low water, 10 ft. and 6 ft. over keel-blocks; depth over keel-blocks at extreme high water, 35 ft.: dock to be so situated that it can be extended 100 ft. The cost is roughly estimated at about 800,000 dols. (£160,000).

Agent for the Destruction of Fungoid Growths.—It is reported by the United States Consul-General at Coburg that a simple and effective agent for the destruction of fungoid growths is being manufactured by a firm at Cassel, and has been put on the market under the name of "mikrosol." Professor Migula, of the same city, has made a thorough examination into the action and effect of mikrosol, and recommends it as very efficient, both for the destruction and prevention of fungoid growths. Mikrosol is easily soluble in water, a 2 per cent. solution applied to wood by means of a brush bringing about the desired effect almost immediately. The preparation ought to be very useful on shipboard, especially in tropical and semi-tropical countries.

Transforming Old Engines into New.—An Aladdin-like transformation of old engines of the 1879 type (having eight wheels, the four intermediate ones being coupled) into non-compound locomotives, drawing the fastest trains on the Paris, Lyons, and Mediterranean Railway, has been effected. This change has chiefly been brought about by (*a*) a shortening of the boiler barrel, (*b*) in fitting ribbed boiler tubes in place of the original smooth kind, (*c*) in substituting a bogie for the leading single axle, and (*d*) by omitting the trailing non-coupled axles, together with a few minor alterations. The fire-box in now fixed between the two coupled axles. The whole thing is said to have resulted in an unqualified success.

The Cheshire Electric Light Company.—A dividend of 4½ per cent. was declared at the annual meeting at Northwich of the Cheshire Electric Light Company. This was a pioneer company of the kingdom, being the first to dispense with steam. They generate with Mond gas, and have entirely banished smoke, a fact which was recommended to the study of local authorities. The chairman (Mr. Thomas Ward) remarked that the total expenses worked out at 2·62*d.* per unit, which was much lower than the corresponding figure of any other English company.

The Electric Furnace and Pig-Iron Manufacture.—Three furnaces of 500 electric horse-power are said to have been erected in the valley of Camonica, Northern Italy, for the manufacture of pig-iron under the Stassano patent. The furnaces in general outlines resemble cupola furnaces using coke, their special features being apparent in the provision made for supplying electric current and in the electrodes placed at the bottom of the boshes. To obtain a ton (metric) of metal, 3,000 horse-power hours are required, which costs about 18 francs.

The American Revolution in Costs of Production.—The first annual report of the U.S. Steel Corporation contains some startling statements, the many changes in method which have already been adopted not only promising for the future most wonderful results, but having already in the present effected a marvellous degree of benefit. Practically speaking, the many economies from manufacturing on a large scale in a thoroughly well-organised consolidation amount to a complete revolution in the costs of production.

Some Projected New Liners.—We hear that two new steamers are to be built for the Atlantic passenger service by the Cunard Company. It is said that these new vessels will surpass anything ever attempted as yet in the British mercantile marine, having a length of 700 feet and a speed of 25 knots, their engines developing 48,000 horse-power.

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In this section is presented every month a concise précis of the contents of the leading organs of the technical press and of the proceedings of the learned societies throughout Great Britain, the Continent, and America.

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MATERIALS OF CONSTRUCTION.

American Notions on Rock Blasting. Being the second part of an article on this subject.—The writer observes that no instance has come to his knowledge of two blasting explosives being used in conjunction, with the object of obtaining disruptive results differing from or better than could be got from one. The system recommended is preliminary explosion of part of the charge and final detonation of the remainder. He complains also of the conservatism in the use of blasting explosives, saying that although there are now dozens of kinds suitable for use in quarries and mines, two only are generally employed, blasting powder and gelignite. It would be to the advantage of each consumer of explosives to discover what will best suit his individual necessities, such knowledge often leading to a reduction of expense. It is stated that the common practice of buying blasting powder in only one size of grain might with advantage be departed from.—*The Quarry*, February 1st, pp. 91, 92.

Sea-water's Effect on Portland Cement.—Excerpts from the paper on "Harbour Construction," read before a recent meeting of the Aberdeen Association of Civil Engineers by Mr. James Barron, C.E. In spite of the late scare about chemical action on cement concrete in the sea, by using the very best quality of cement and by carefully regulating and adjusting the aggregates of concrete to meet the various requirements of the work, satisfactory results are invariably obtained. The writer comments on the changes which have taken place in the description of materials used for quays and piers, which are largely due to the introduction of iron and steel, and more especially to concrete made with Portland cement. — *The Quarry*, February 1st, p. 90.

Recent Data concerning Concrete Beams and Concrete Floors.—Paper read before the Northern Architectural Association at Newcastle by Mr. James Bruce. The largely increasing use of this material is chiefly due to the improvements in the manufacture of Portland cement, principally as regards the extreme fineness to which it is now ground. It is said that it is now possible to obtain cement which leaves less than 10 per cent. residue on a sieve of 32,200 meshes to the square inch, and it is asserted that extreme fineness of grinding makes for strength. The extra cost involved by the additional grinding is only about six shillings a ton. After reviewing some experiments, made to discover the proportions of voids in different kinds of aggregate, Mr. Bruce observes that concrete is too often made with an insufficiency of mortar to fill all the voids, and in cases where the material is to be used for beams and flooring slabs this is altogether fatal to its strength. Some actual experimental data concerning concrete slabs are given. *The Builders' Journal*, Jan. 29th, pp. 422-424. (Ill.)

Kilns.—Paper read by Mr. R. Thomson before the West of Scotland Iron and Steel Institute. It deals with the new type of regenerative continuous kiln, which has advantages over those now generally in use. After enumerating the various and serious drawbacks of the latter—all of which are due practically to a violation of the importance of the ability to regulate the air supply to suit combustion requirements—he proceeds to explain the principles of the new type. The kiln of the future must utilise both the heat of the combustion gases and the whole of the regeneratively heated air supply, acting as drier as well as kiln. Combining the efficiency of the continuous kiln with the accuracy of the independent type, it must be able not only to receive material direct from the machine, but dry and fire them without stain, fire-soak and anneal them, besides being able to deal with *all* classes of goods in an equally thorough manner. All this it must be able to accomplish whilst yielding a much greater output than is possible with the present kilns. The primary step towards

overcoming the existing difficulties is to secure absolute control of the draught of the kiln, and provide for the facile regulation of the collection and distribution of the regeneratively heated gas supply. Whilst the continuous system is eminently adapted for *accurate* working, the necessary control can only be secured by the employment of mechanical means. In order to obtain all the benefits of the new system it is necessary to provide for the efficient regulation and control of the regeneratively heated air in a properly-designed kiln, mechanically equipped. A long and detailed description of such a kiln (the one explained has just been built at Bothwell Park Quarries and Brickworks, Fallside) follows. It is a down-draught, multi-chamber (in this case twenty) continuous kiln. Each chamber is provided with two collecting and distributing flues, each being in valve-controlled communication with a hot-air conduit common to all, and one of which is in damper-controlled connection with the exhaust flue. The chambers can be separated from each other by dampers. One of the most noteworthy among the advantages of this new invention is that combustion can be conducted simultaneously in several serially-adjoining chambers in tandem, this meaning that the firing capacity of the kiln is enormously increased, each single chamber thus under fire representing by itself the whole of the firing capacity of any ordinary continuous kiln. The complete provision made for the utilisation of the regenerated heat and the heat of the combustion gases enables the kiln to be worked with a minimum of fuel.—*The British Clayworker*, Feb., pp. 391-96. (Ill.)

The History, Manufacture, Testing, and Uses of Portand Cement.—Being a paper read by H. Howard Humphreys, M.I.Mech.E., before the Architectural Association.—*The Quarry*, February 1st, pp. 106-9.

BUILDING CONSTRUCTION.

CIVIL ENGINEERING.

1. Bridges and Viaducts.

The Chippewa Falls Highway Bridge.—The bridge dealt with was one replacing on the same site a narrower erection having practically the same span, the new superstructure being supported on three of the old channel piers and on two similar new ones. The successful way in which the operation was accomplished is fully detailed in *The Engineering Record* of January 25th, pp. 78, 79. (Ill.)

The New Subway in New York City. The continuation of this series of articles, by Mr. Charles Prelini, C.E., New York, is a leading feature in *Engineering*, Feb. 21st, pp. 245, 246.

2. Canals, Rivers, and Harbours.

MUNICIPAL, SANITARY AND GAS ENGINEERING.

Some Economical Features in Municipal Engineering.—By Mr. C. S. Burns, Assoc.M.Am.Soc.C.E. (of Burns & McDonnell, Kansas City, Mo.) Mr. Burns devotes much attention to explaining the economic relation between the different parts of a system of waterworks, taking a case for consideration in which the rate for pumping is: 2800 gals. per minute for six hours per day, 1400 gals. per minute for six hours per day, 800 gals. per minute for six hours per day, and 300 gals. for six hours per day. The pumping station being 4,000 ft. from the branching point of the distribution system, it is necessary to determine the most economical size of main for this distance, and for that particular location, it is found, from detailed calculation, to be the 16-in. pipe. Mr. Burns, in giving this example, does not, of course, wish his calculations to be taken as a general guide. Another point raised is the attempted economy in the spacing of fire hydrants, the popular idea being that these should be spaced as far apart as possible, in order to economise in the number used; but in a system of waterworks owned by the municipality, designed to give fire protection without the use of steamers, there can be no possible justification for spacing the hydrants at such great distances. The various details would naturally vary with the plan of the pipe system, and other conditions. In one system cited by the writer, the hydrants were from five to six hundred feet apart, but by increasing their number these distances were reduced to three hundred feet, effecting a saving of about a hundred feet of hose, and, in addition, important economy from being able to secure the required fire protection with less pressure, appearing in the reduced maintenance charges, less leakage and other important advantages.—*The Engineering Record*, Feb. 8th, pp. 126, 127.

A Continuous Process for Making Mixed Gas of Uniform Composition.—Translation of a paper contributed by Dr. Besemfelder, of Charlottenburg, to the *Journal für Gasbeleuchtung*. Besides a description of his new method, the doctor gives a most readable review of the principles which underlie the working of other well-known processes.—*Journal of Gas Lighting*, Jan. 21st, pp. 146, 147.

ELECTRICAL ENGINEERING.

1. Physics.

The Spectrum of the Enclosed Arc: being some interesting personal observations made by Dr. Louis Bell.—The striking thing about the spectrum of the enclosed arc is the very great relative brilliancy of the discontinuous arc spectrum. The results of Dr. Bell's experiment are fully explained, an accompanying diagram lending no small aid.—*Electrical World and Engineer*, Feb. 1st, p. 195.

Magnetic Deflection of Long Steel-Wire Plumb-Lines.—By Dr. Wm. Hallock, in the research shaft at Columbia University. The question arose from the extraordinary deflection observed in a case under consideration, and it struck the writer that besides a magnetization of the wires, and a consequent repulsion of the two north poles at the bottom, the enormous magnetising influence might be partly owing to the masses of iron in the shaft. As a result of his experiments, described in detail, Dr. Hallock arrived at the conclusion that iron or steel wire ought not to be used for plumb-lines where accuracy is needed, as they are deflected by the earth's field as well as by each other. A possible substitute is suggested in phosphor bronze, which would prove most useful where great tensile strength is required.—*Electrical World and Engineer*, February 8th, p. 263.

2. Electro-Chemistry and Metallurgy.

The Corbin Process and Cell for the Electrolytic Production of Chlorates.—A descriptive article, by John B. C. Kershaw, F.I.C., of the work in operation at Chedde, in Savoy. The Corbin type of chlorate cell is said to be admirably designed to bring about the reaction between chlorine and sodium hydrate, upon which the formation of the chlorate depends. Recently it has been discovered that far higher efficiencies could be obtained in electrolytic cells if the reducing action of the hydrogen liberated at the cathode were suppressed, it being possible to effect this by the addition of alkaline carbonates, of calcium chloride and potassium chromate to the electrolyte. It was indeed found by Brochet that the addition of chromates to the electrolyte diminished the reduction losses at the cathode quite 87 per cent. It is extremely probable that one of the above additions is made in the Chedde works, for the standard of current efficiency stands as high as 85 per cent., and it is hoped that eventually 90 will be reached. The chlorate and per-chlorates produced here are much employed in the manufacture of the new explosive, "Cheddite," and already factories for this manufacture are established in France, Switzerland, Italy, and Greece.—*The Electrical Review*, Jan. 17th, pp. 83, 84. (Ill.)

The Dry Cell.—Tabulated results of tests made in connection with the "dry" cell. Although the materials of which it is composed are well known, the construction of the various cells similar, and one might consequently expect the products of the various makers to be alike, defective workmanship was exposed in a number under examination. Therefore, when any very great investment is intended to be made in their purchase, tests of efficiency are of very significant value.—*Electrical World and Engineer*, Jan. 25th, p. 156.

3. Measurement.

4. Electrical Machinery.

Tests of a Compensated Asynchronous Motor.—The account of these interesting experiments serves to show that the first compensated motor really possesses the properties theoretically foreshadowed in a previous article by the present writer, Alexander Heyland. The motor under investigation was connected as a single-phase motor, leaving, however, two phases of the star-winding in series. The third phase was disconnected, a part of it being used for the excitation. It was possible in this way, by changing the connections, to arrange the different turns of this phase in series or parallel, and so obtain different voltages and currents as desired, and adjust the compensation as required. The tests consist in determining, firstly, the position of the brushes giving a minimum phase displacement, and then the number of turns of exciting winding just sufficient to prevent all phase displacement.—*The Electrician*, Jan. 24th, 530, 531. (Ill.)

5. Power Transmission.

6. Electric Lighting and Heating.

Electricity in Glass Manufacture.—A new form of glass furnace, in which electricity replaces gaseous fuel as the source of heat, is being experimented with in Germany. Although the modern form of the latter-named is so essentially a heat economiser that the electric furnace will not be able to compete with it in localities where coal is cheap, for some kinds of glass manufacture the regenerative gas furnace is not suitable. Also, in many parts of Europe, fuel is far too costly to enable this manufacture to be carried on at a profit by that method. Therefore and in these cases, where electric power derived from falling water is usually available, the present tests may lead to some very tangible results. The subject, too, is intimately connected with the future of an old English industry; for as fuel becomes dearer there is every probability of a transfer of the glass manufacture from Lancashire and Yorkshire to Switzerland and Norway. The electric furnace for glass production is said to overcome the present system's disadvantages of (*a*) costly furnaces, (*b*) heavy repairs, (*c*) the rapid deterioration of the furnaces, (*d*) intermittent work, and (*e*) unhealthiness. The last two-named, however, it should be stated, refer only to the working of pot furnaces. The Becker electric furnace (experimented with at Cologne), and two other new forms suitable for laboratory use, are described in the article, with the illustration of several diagrams.—*The Engineer*, Feb. 14th, p. 160. (Ill.)

7. Telegraphy and Telephony.

The Imperial Cable.—A pleasantly discursive article on cables in general, and more particularly the all-British cable, now in process of construction, about which such profound secrecy is being maintained. This Imperial cable (to be employed for strategic as well as

other purposes) is not only to be the largest ever undertaken, but it is also to be quite a new departure in politics. The property of the States concerned — Britain, Canada, New Zealand, and Australia—all its stations are to be under the British flag. The Vancouver to Fanning section—on the lines of the Anglo-American cable of 1894—is said to be the most interesting from the engineering point of view. The originator of the "great emprise" was Sir Sandford Fleming, the distinguished engineer of the Canadian Pacific Railway. — *The Engineer*, Feb. 21st, p. 179.

The Economic Design and Management of Telephone Exchanges. III. By Arthur V. Abbott, C.E.—The method for the determination of the telephonic centre, described in the previous number, is here enlarged upon. —*Electrical World and Engineer*, Feb. 8th, pp. 266, 267. (Ill.)

8. Conducting Materials and Methods.

Practical Notes on Continuous-Current Distributing Mains.—Paper delivered before the Glasgow Section of the Institution of Electrical Engineers, on January 14th. The choice of a suitable system of distributing mains is a most important problem, a great difference of opinion existing among engineers as to the merits of the individual systems. Until quite recently, the systems of distributions have not received their just due of attention. Some localities and conditions permit of a certain system to be employed with advantage, which elsewhere and under different conditions would result in failure. For example, in a small town, where there is plenty of room under the footways for the laying of mains, and where straight runs and required gradients can easily be obtained, a copper-strip system would prove very successful, but, placing that same system in a large town it would be found that numberless difficulties would present themselves. The few but very important points affecting the efficiency of continuous-current distributions are carefully considered, the causes and remedies for various possible breakings-down being treated in detail. —*The Electrician*, Jan. 24th, pp. 543-5. (Ill.)

Earth Currents derived from Distributing Systems: being a reprint of a paper read by Mr. E. Basil Wedmore, on January 23rd, before the Institution of Electrical Engineers. He begins with a consideration of the current distribution accompanying the use of the earth as a return in a simple traction system, approaching the subject from the magnetic side.—*The Electrician*, Jan. 24th, pp. 541-3.

Earth Currents Derived from Distributing Systems.—Being the continuation and conclusion of the paper read by Mr. E. Basil Wedmore, before the Institution of Electrical Engineers, on January 23rd (in which the conditions holding in the immediate neighbourhood of the track where the current densities are greatest is considered, and various detailed calculations given), together with an abstract of the discussion which took place in its connection, in which Dr. R. T. Glazebrook, Mr. A. P. Trotter, Mr. E. Parry, Messrs. E. O. and S. F. Walker, Professor A. J. S. Adams, and Mr. W. M. Mordey took part. An important key for future investigation on a subject of which too little is known. — *The Electrican*, Jan. 31, pp. 568-71. (Ill.)

9. Electric Traction.

Inertia of the Rotating Parts of a Train. —A communication presented at the January meeting of the American Institute of Electrical Engineers by Norman Wilson Storer. In order to estimate precisely the motor capacity and amount of power necessary to maintain a certain train service, it is necessary to find out exactly how the motor force is expended, *i.e.* how much of it is employed in overcoming (*a*) train resistance, (*b*) the force of gravity, and (*c*) inertia. The first can only be allowed for approximately, and although it is possible to estimate the two latter to a nicety, it is but seldom that the inertia is correctly calculated. In this last-named factor one important point has, as a matter of fact, always been overlooked: this is the inertia of the rotating parts of the train. Recently, however, the subject has met with some investigation, by means of which it has been found that the wheels, with their low speed and the armatures (which generally revolve at a much higher rate than the wheels), together constitute a consideration of vast importance in the determination of the power required for operating the train. From a number of observations taken, it has been discovered that the flywheel effect of the rotating part of an electric car averages about 10 per cent. of the inertia of the whole weight of the train, which means that 10 per cent. more energy is stored in every train than is accounted for by the dead weight, 10 per cent. more power is required for accelerating, and 10 per cent. more energy lost in breaking, and the train resistance measured by the retardation in coasting is 10 per cent. below the true resistance. Of course, it is admitted that any fair engineer can give a calculation of the power required for a given service; but where a complete accuracy is required, the most reliable estimate for train resistance should be used, the inertia of the rotating parts carefully considered, and the weight of the entire train noted before any large equipment is decided upon.—*Electrical World and Engineer*, Feb. 1st, pp. 221, 222.

Tractive Effort on Electric Tramways. By W. H. Booth.—The average power per car on an electric tramway is now fairly well known, a good English average being one unit per car-mile for single-truck cars of 7 to 8 tons weight, whilst the average current consumption per car of a given weight closely approximates 1 h.p. per ton at the switchboard where the distribution system has been well provided. As the mechanical and electrical efficiency of a car may be taken as a minimum 33 per cent., the mean tractive resistance comes out somewhere between

22 lbs. and 66 lbs. per ton, and, assuming the motor and gearing to be responsible for 50 per cent. efficiency, the resistance of the car as a carriage merely would appear to be 33 lbs. per ton on average tramways. The use of gears at one end of the armature spindle only is alleged as an important reason for the poor efficiency of the car mechanism. The result of tests was shown to be that the internal car resistance is probably greater than its axle and rail resistance, and it is stated that car mechanism ought to be more carefully made and better lubricated than heretofore has been the custom.—*The Tramway and Railway World*, Feb. 13th, pp. 85, 86.

Electric Car Equipments and their Maintenance.—By A. W. Wigram. Being an abstract of the paper read at the Newcastle local section of the Institution of Electrical Engineers. Trucks, brakes, lifeguards, motor equipment, trolley heads, trolley standards, and controllers are the points treated. The writer expresses a strong objection to maximum traction trucks, and also to rheostatic brakes, considering that the ordinary hand-brake, properly designed, leaves little to be desired for light cars. Air-brakes he considers useless. It is said that the American system of running all the leads from the controllers in a canvas hose is going out, being replaced by a system of separate multi-core cables.—*The Electrician*, Jan. 24th, pp. 539-541.

10. Central Stations.

Reconstructing, or Modernising, Central Stations.—A paper on this subject, read by O. M. Rau before the North-Western Electrical Association, rightly pointed out that the steam equipment as a rule receives its due share of attention, the introduction of modern devices being quite common, whilst a totally different state of things prevails in connection with the electrical apparatus. The difficult question, in a consideration of this matter, arises as to what to keep and what to throw away. For the average central station and isolated plants Mr. Rau recommends the alternating current, the high state of efficiency in connection with the apparatus of which leaves nothing to be desired. A single generator, covering all classes of service required, taking the place of the old assortment and, either direct-connected or direct-belted, settles the shafting question. A long and explanatory account of the course to be pursued follows. Mr. Rau's many valuable suggestions should go far towards helping those interested in the matter under discussion.—*Electrical Review*, Jan. 25th, pp. 120, 121.

MARINE ENGINEERING AND NAVAL ARCHITECTURE.

1. Vessels.

The Cross-Channel Passenger Steamship Services. No. XI.—This instalment is mainly taken up with a description of the Royal Mail twin-screw steamer *Arundel* and her propelling plant. This steamer may be taken as typical of the future class of new ships to be employed in the Newhaven-Dieppe service, being built by Denny Bros., of Dumbarton. The vessel is 276 ft. 10 ins. long, with a moulded breadth of 34 ft. and a depth to under-side of promenade deck of 22 ft., the hull being built throughout of mild steel, subdivided (as a safeguard against accidents) into a large number of separate water-tight compartments, especially deep-bilge keels providing against any tendency to excess in rolling in a seaway. The arrangements of the lower, main, and promenade decks and the partial shade deck are those similar to the ones in all first-class Channel steamers, whilst the propelling machinery consists of two complete sets of four inverted-cylinder triple-expansion screw engines, the cylinders being 23½ ins. diameter for high-pressure, 35½ ins. for intermediate pressure, and 37½ ins. for the two low-pressure cylinders, all having a piston-stroke of 2 ft. 3 ins.—*The Engineer*, Feb. 21st, pp. 180-183. (Ill.)

Tow-Barges as General Freight Carriers.—A consideration of barges as freight carriers, and more particularly for sea service, now rendered safe and possible by the invention of the towing-machine by Mr. T. Jackson Shaw in 1888. It is the writer's firm conviction that if long-distance towing were properly developed large profits would be made by those embarking on this means of transportation. In America this system of freight-carrying is most successfully employed to a very large extent. The Reading Railway Co., as an example, have a large fleet of barges trading between Philadelphia and eastern parts, a tug-boat or towing-steamer of 170 ft. length and engines of 1,000 h.p. in this service conveying three, or even four, barges, of 16,000 tons capacity each, to a distance of 500 miles, returning with empty barges in six and a half days. A comparison is instituted between the cost of this mode of transportation and the prices now charged for full cargoes of the cheapest class of freight.—*Marine Engineering*, Feb., pp. 70, 71. (Ill.)

2. Engines and Equipment.

The Theoretical and Practical Methods of Balancing Marine Engines.—Abstract of Naval Constructor D. W. Taylor's prize paper delivered before the Society of Naval Architects and Marine Engineers. Only a first instalment of his paper is presented to us here, but it is accompanied by a wealth of diagram and illustrative tables.—*Marine Engineering*, February, pp. 59-66.

MECHANICAL ENGINEERING.

1. Boilers, Furnaces and Fuel.

The Control of Steam Superheaters.—Although our Continental neighbours are always exclaiming that our engineers do not support the superheating of steam to any extent in connection with the large installations where

steam power has long been used, it is nevertheless a fact that in most of the modern installations of steam-power in this country the superheating of steam is provided for in the specifications of the engineer. It is particularly to be noted, however, that these examples are from installations of modern equipment that can be obtained from the Continent; for there are, comparatively speaking, but few engines of old design that could be safely or conveniently employed where superheated steam was used at the exceedingly high temperature so common abroad. As a matter of fact, it would not be possible to introduce superheated steam, having a temperature of 550 degs. Fahr., into the great majority of our home-constructed engines, for the reason that the packings would be immediately destroyed by such a temperature, and mineral oil with its flash point at 600 degs. Fahr. would be rendered altogether useless as a lubricant. It is said that the uttermost limit to which superheating can safely be carried in this country is 500 degs. Fahr.; and it is therefore highly necessary that this temperature should never be exceeded, else abrasion of the working parts and damage from the scoring of piston-rods through charred packing are bound to occur. Until satisfactory means are provided for preventing superheaters from imparting an unsafe and excessive degree of superheat to the steam to be used, the owners of engines will be found reluctant for their adoption.—*The Practical Engineer*, February 14th, pp. 145, 146.

Feed-Water Heaters in Condensing Plants.—By C. E. Robbins. Being a detailed article dealing with the proper proportioning of the heating surface of the same apparatus, together with illustrative tables. The problem briefly is stated to be:—A given number of pounds of water, dependent upon the boiler h.p., is to be raised from a certain initial temperature to a final temperature as near as possible to the temperature of the exhaust steam. In order to do this it is necessary to take from the steam a certain number of heat-units. As it requires one heat-unit (B.T.U.) to increase the temperature of 1 lb. of water 1 deg. Fahr., the quantity of heat to be transferred is easily to be found by multiplying the total pounds of water by the rise in temperature. If we knew how many heat-units would be transferred by each square foot of heater surface the desired number of square feet of surface could of course be at once discovered by simple division, but it is precisely at this point that the complication and uncertainty comes in, the quantity of heat transferred per square foot per hour varying widely and depending upon the material, arrangement, and condition of the surface, the manner in which the water is applied (whether inside or outside in tubes), the velocity of the water, the difference in temperature between the steam and the water, and many other things. By many engineers and writers the average temperature of the water is taken as half the sum of the initial and final temperatures, the degrees of difference being found by subtracting this average water temperature from the temperature of the steam. The method of calculating surface, given by Mr. Lewis (*Power*, Dec., 1901), has the merit of great simplicity. Mr. Robbins illustrates it here, as also the method of Mr. Hepburn, which he considers undoubtedly to be more scientific. It would appear that the rational method of proportioning heaters for a condensing plant, when plenty of pump exhaust is available, is to proportion first the atmospheric heater to use as much of the pump exhaust as can be safely counted upon, next to find the minimum temperature of the entering water which this amount of heat will allow, and then to instal vacuum heaters to raise the water from the initial to this temperature, at which it enters the atmospheric heater. A numerical example is shown. An estimation of the quantity of pump exhausts is also shown, but this, of course, depends altogether on the number and kind of the auxiliaries, a guaranteed statement concerning which should be obtained from the manufacturers. A second table, given for convenience in calculating the required surface, will be found of great utility.—*Power*, Feb., pp. 13-15.

2. Prime Movers.

The Alcohol Motor.—Some instructive experiments were recently made in connection with these in the gas-engine laboratory of the Technical High School of Berlin, and whilst scientifically accurate determinations were not attempted, some most interesting facts, commercially speaking, were arrived at. The experiments were made with a 4-h.p. alcohol engine coupled to a dynamo, constructed by the Brothers Körting, and resulted in the acquired knowledge that the alcohol motor is 45 per cent. dearer than the gas engine, 48 per cent. more so than the heavy oil motor, 6 per cent. more than the benzine motor, 53½ per cent. more than the acetylene variety, and 31½ per cent. more expensive than the electric. When compared with petroleum and benzine motors, the alcohol motor has the unmistakable advantage of constancy in the price of fuel, besides an absence of all smell. It is thought that whilst no great future is to be hoped for with the stationary alcohol motor, for automobile purposes, when used with a mixture of benzine, it will probably hold its own.—Ernst Neuberg, in *The Automotor Journal*, Feb., pp. 194-6.

A New Balanced Engine. — This new system of counterbalancing the reciprocating parts of engines has been successfully worked on by Mr. M. N. Ferney, M.Am.Soc.M.E. The usual method of counterbalancing, by the attachment of counterweights to the main shaft of the engine, opposite to the crank or cranks, serves to counteract the momentum of the piston and its connected parts in their rectilineal movement, but as the weights must necessarily traverse a circular path they cause a disturbing action on the shaft at right angles to the direction of movement of the piston. The new form of engine is designed to eliminate this disturbing action, at the same time dispensing with the

ordinary cross-head and guides, reducing the length of an engine to one-half of the ordinary forms. This is accomplished by means of a system of levers forming a parallel motion, to which the piston-rod and connecting-rod are attached, causing them to move in directions opposite to each other, so that the rectilineal momentum of one counteracts that of the other. The counterweights may consequently be greatly reduced, as the one part serves to balance the other.—*The Engineering Record.* January 25th, pp. 88, 89. (Ill.)

A New Apparatus for Measuring the Variation of Speed of a Fly-wheel during One Revolution.—An ingenious invention, fully explained by Mr. E. W. Mix.—*Electrical World and Engineer*, February 8th, p. 264.

Exhaust Outlets on Vertical Engines. By W. E. Crane.—Dealing with the mistakes made in the placing of exhaust outlets.—*Power*, F b. 1902, pp. 11, 12. (Ill.)

The Calculation of Clearance Volumes. By Horace Holden Thayer, Jun.—Two methods of performing the above task are herein dealt with. In one the volume is measured by plugging up any openings in the cylinder and valve-chest, the cylinder being filled with oil or water. If the experiment is being made in the machine shop the valve openings most particularly have to be plugged, and on subtracting from the volume measured the piston displacement and the volume of the piston and piston rod, or volume of the piston, piston rod, and tail rod—when the latter is employed—the measure of the clearance of both ends is arrived at. The clearance at either end may be found independently of these deductions in a comparatively easy fashion by making a detailed calculation from drawings, and it is stated that this method can be used to obtain quite quickly wholly accurate results. The system is fully described with diagram aid. It is said that this way of calculating the clearance volume permits of independent calculations for the two ends of the cylinder, and can be carried to any desired degree of accuracy, besides being, with a little change, equally applicable to any other case.—*Marine Engineering*, Feb., pp. 67, 68. (Ill.)

The Advantages and Disadvantages of the Steam Jacket.—As the function of the steam jacket and its precise degree of utility is unagreed upon, it is interesting to note the various pros and cons. The at one time common idea that a cylinder should be jacketed with exhaust steam, because that steam is hotter than the surrounding atmosphere, is now exploded, it being generally understood that the question is one mainly of flow of heat, and that a smaller number of heat-units will pass out through a jacket of air—or other non-conducting material—confined against the cylinder, than would be carried away by a continuous flow of exhaust steam. For while in the first case the cylinder has to heat up once to its own temperature the surrounding jacket and then has only to supply the very small amount of heat which will find its way through this jacket, in the latter instance the cylinder has constantly to supply heat to be carried off by a current of exhaust steam. The office of the steam jacket is to keep the temperature of the cylinder walls as near as possible to that of the working steam. An effective non-conducting jacket can be used although the temperature of the cylinder may be raised. The radiation inward is helpful during the working stroke, and less heat will be carried off by the dry exhaust from the dry surfaces than would be the case if those surfaces had to furnish heat for the evaporation of a quantity of water. Under what circumstances, then, it is queried, is a steam jacket likely to be beneficial? This is answered in countless ways, some maintaining that the steam jacket never saves enough to make its complication and expense worth while, others using it on the high-pressure cylinder of a compound engine, others on the low and not on the high at all, and others, again, using it on all the cylinders. As a matter of fact, the value of the jacket decreases with the increase in speed. Since compounding is designed to diminish loss by cylinder condensation the jacket would appear to be of less utility on a multiple-expansion than upon a simple engine, not more than 3½ per cent. of the available tests resulting in favour of the jacket on the cylinders of a large compound. Where—as in Europe—it is customary to have the steam passed through the jacket on its way to the cylinder, the gain due to the return of the hot water (which amounts to one-half as much as that due to the itself jacket) is sacrificed.—*Power*, Feb., p. 18.

3. Hydraulics.

4. Power Transmission.

5. Machine Shops and Foundry.

6. Tools.

7. Refrigeration and Cold Storage.

8. Miscellaneous.

Motive Power from Blast Furnace Gases.—*Résumé* of a paper delivered by Mr. Bryan Donkin before the Institution of Civil Engineers. As is generally known, this gas at the present time is partly employed for heating the hot-air stoves and for raising steam by combustion under boilers, but by its direct employment in internal combustion engines four times this amount of power could be obtained. It is said to be probable that the adoption of closed tops to the furnaces (where they do not already exist) will now become more universal, as will also the installation of gas engines. Blast-furnace gas is far from satisfactory for heating air-blast stoves, because of its low thermal value and the quantity of dust, and it would be far more economical to employ common producer gas from slack coal, reserving the blast-furnace gas for more profitable work in gas engines. In this connection it would have a high thermal

value, whilst the common producer gas would be more efficient from a heating point of view. According to the present system quite 10 per cent. of these gases is lost by leakage, 28 per cent is applied to heat the air-blast, 40 per cent. to the boilers, and 22 per cent. is altogether wasted. The most notable point in the application of blast-furnace gas to internal combustion in gas engines is the removal of the dust carried by the gas from the furnace.—*The Electrical Review*, Jan. 17th, pp. 81, 82.

The Designing of Cranes and Crane Details. Part III.—*The Mechanical World*, Feb. 14th, pp. 78, 79. (Ill.)

MINING AND METALLURGY.

The Micro-Structure of Metals.—This paper, read at a recent meeting of the Institution of Mechanical Engineers, shows the utility of the microscopical examination of copper and tin alloys as a factor in metallurgical progress. Although the physical properties of a metal or alloy depend upon its chemical composition (this composition being found to be right, the metal generally meeting all requirements), it occasionally happens that even when the composition is correct, metals fail in actual practice. Steels here are more particularly indicated. It is here that the microscope comes in with its invaluable aid. Steel may be subjected to many different treatments which, though affecting very considerably its mechanical or physical properties, have absolutely no effect whatsoever on its chemical composition. The *structure* of a metal (not to be confounded with its *fracture*) is clearly shown to be of as much importance as its composition, indicating as they do the actual crystalline condition of the metal tested. The method of examination is very fully entered upon, the process followed in the preparation for such examination being described in detail.—*The Practical Engineer*, Feb. 14th, pp. 151, 152.

NAVAL AND MILITARY ENGINEERING.

RAILWAYS AND TRAMWAYS.

1. Permanent Way Works and Construction.

Mining Methods in the New York Subway.—By D. H. Newland. The writer deals in a fully explanatory manner with his subject. The subway—which is to afford a quick transit between the distant parts of Manhattan Island and the proposed tunnel under the North and East rivers, and furnishing a direct railway communication with New Jersey and Long Island—is now in an advanced state of development, the actual work being commenced about 16 months ago. The general plan calls for a shallow excavation, following the surface as closely as possible and, although the difficulties of this method are greater than if the tunnel were driven to greater depths, the usefulness of the subway would have been lessened by an adoption of the other method, since the short distance travel could not so easily have been provided for. The subway is to have an underground length of about 15 miles, the total amount of material to be excavated having been estimated at about 2,990,000 cub. yds., of which 1,700,000 are of earth. Tunnelling is to be partially employed in the removal of the rock. A Lidgerwood cableway and hoisting engine is employed for dealing with the loose earth. Both the top-heading and bottom-heading methods are being employed, the latter, however, being found more economical. The drills used in the tunnels are of the percussion type, and for mixing the concrete a gravity apparatus of great simplicity has been adopted. It consists of an inclined sheet-iron or steel trough, rectangular in section, rigged with hard steel baffle-plates. The sand, stone, and cement are shovelled in proper proportions into the top of the trough and, striking against the baffle-plates in their descent, are thoroughly mixed, the requisite water being introduced by means of a pipe at the top. The steel required for the permanent structure of the subway amounts to 65,000 tons.—*The Engineering and Mining Journal*, Feb. 1st, pp. 174-77.

The Uganda Railway.—A paper read before the Society of Arts by Commander B. Whitehouse, R.N. The extraordinary experiences of the chief engineer and his staff over this pioneer-work, and the remarkable conditions under which the railway was formed, make quite entertaining reading. The difficulties encountered were almost insuperable. There was the importation of 20,000 Punjabis, and the supplying of them with the food of their native country, and whilst both officers and men fell victims to fever and small-pox, the great engineering strike in England rendered it difficult to get material and locomotives. All the officers had to become acquainted with the two languages used on the line, and, to add to their trials, a famine raged among the natives, lasting for two years. The journey from Mombassa to Port Florence will, on the opening of the whole line, take two days and a-half only, with another day for the steamer journey to Mengo, the capital of Uganda, making three and a-half days in all, as against the seventy required by the old caravan route.—*Journal of the Society of Arts*, February 14th, pp. 229-238.

Bridge Testing. An article dealing with the tests, preliminary and periodic, of bridges.—Given the intention of ascertaining (*a*) whether a structure be strong enough to carry a certain load, and (*b*) if at any later date the bridge be less able to bear the said load, it would appear that a mere knowledge of the deflection under moving loads is in itself insufficient, although the various small deflections observed doubtlessly give some indication as to the rigidity, the state of riveting, etc., of the joints, and the stability of the structure. Nor does the fact of there being at a subsequent date any greater deflection than at first prove there to be anything wrong. The real necessity is for ascertaining

the actual distribution of stresses in a complex structure, and although this can partly be effected by the extensometer, it is not an entirely satisfactory way. The most common method of measuring deflections is found to be the use of a graduated staff fixed to the bridge under examination, the staff being displaced as the deflection occurs, these deflections on the staff being measured by means of a telescope. Neither the preliminary nor periodic tests are considered by many of the American engineers to be of any use, and in several of the States they are not employed.—*The Engineer*, Feb. 14th, p. 157.

2. Locomotive Power and Equipment.

Express Engines, Furness Railway.—A description of some very powerful express bogie passenger engines, built for the Furness Railway Company, by Sharp, Stewart & Co., of Glasgow, to the designs of Mr. W. F. Pettigrew, M.Inst.C.E., the locomotive engineer of the company. The special and notable features to be observed are (*a*) the employment of a special type of blast pipe, designed by Mr. Pettigrew after a long series of experiments, which, combined with the improved valve motion, has succeeded in effecting a considerable reduction of the coal consumption, and (*b*) the arrangement of spring gear of the driving and trailing wheels. Compensating beams, or equalising levers, are used between the springs of the coupled wheels. The springs themselves are long. The principal dimensions of the engines are presented in a tabulated form, sectional drawings of the same being published as a supplement.—*The Engineer*, Feb. 21st, p. 194.

Locomotive Working Drawings at South Kensington.—An interesting description of the nineteen original working drawings of the locomotives built by R. Stephenson & Co. between (about) 1827 and 1834. These valuable records have recently been acquired by the authorities of South Kensington Museum, and they are now on view in the Mechanical Engineering Collection, Science Division.—*The Engineer*, Feb. 14th, p. 163.

British and French Train Services in 1901. By Charles Rous-Marten. A review of the principal train services as scheduled in the official time-books for 1901. This first article of the series deals with British railways.—*The Engineer*, February 14, p. 155.

British and French Train Services in 1901.—No. 2 of the series. M. Charles Rous-Marten has occasion here to express his regret that our annual reference-books should so literally teem with inaccuracies as to figures and information with regard to train services. The "Daily Mail Year-Book," however, would appear to be a happy exception. Lists are appended of the longest non-stopping express runs in Britain and France, as also the fastest booked runs on the railways of these countries, no booked speed below 50 miles an hour from start to stop being counted as "express" in the latter connection.—*The Engineer*, Feb 21st, p. 187.

Plate Springs.—The result of an extensive investigation of plate springs as actually made, the ordinary formulæ for plate springs being exceedingly unsatisfactory, the result of their being obtained from a consideration of springs of a type never in use. The article will be particularly acceptable to those responsible for the designing of such springs, to whom also the comprehensive table included will be of invaluable assistance.—*The Engineer*, February 14, p. 157. (Ill.)

The Design and Construction of Railway Carriages in India.—By C. F. Bamford, Assoc.M.Inst.C.E. The object of which is to direct attention to the design and construction of the different railway passenger carriages used on the Assam-Bengal Railway—metre-gauge—and also to those generally in use on other Indian broad and metre-gauge railways. Classifying the list of carriages used on the Assam-Bengal Railway, the writer gives an account of the first-class inspection bogie-carriages. These are for the convenience of railway and Government officials during their tours of inspection on the line. As these tours very frequently extend over a considerable time—sojourns being made at places where no accommodation whatever can be obtained—arrangements for cooking, sleeping, bath and lavatory have to be included. Such a carriage is built up on an ordinary steel under-frame—eight-wheel bogie type—the distance between centres of bogies being 23 ft., and the wheel-base of each bogie 4 ft. 6 ins. The diameter of the wheels is 2 ft. 4 ins. over tread. The double-page supplement plate illustrates the subject under discussion. In the following issue, the first and second class composite bogie carriage is to be dealt with.—*Engineering*, Feb. 21st, pp. 235, 236. (Ill.)

3. Tramways.

The Progress in Street Railway Track Construction. By Charles S. Butts, C.E.—The methods of track welding, with other matters, are fully explained in detail.—*Street Railway Journal*, February, pp. 101, 102.

MISCELLANEOUS.

Ideal Plumbing. I.—The commencement of a series by G. A. Allan, plumbing here being used in the American sense, which includes drains and hot water supply.—*The Builders' Journal and Architectural Record*, February 5th, pp. 437, 438. (Ill.)

Water-Raising Methods, Old and New. Part III. By Philip R. Björling.—In this number the dale, or auge, a machine frequently employed in India, as is also the single môt (for raising water for irrigation purposes), the double môt, the zig-zag, the Persian-wheel (of very ancient origin, its invention being ascribed to the Chinese), the rag-and-chain pump, the sakich, or sakia (a modification of the Persian-wheel used in Egypt for irrigation purposes), and the stream, or Chinese, wheel, are the interesting specimens described.—*Water*, Feb. 15th, pp. 54-58. (Ill.)

REVIEWS.

Die Partiellen Differential-Gleichungen der Mathematischen Physik. The Partial Differential Equations of Mathematical Physics, founded on Riemann's lectures, by H. Weber. Friedrich Vieweg und Sohn, Brunswick. Vol. I., 1900, 506 pp., 10 Mark. Vol. II., 1901, 527 pp., 10 Mark.

This is a work which meets a want that is being every day more and more widely felt by that large class of engineers and physicists whose mathematical knowledge is of too limited a character to enable them to follow much recent work in which they would otherwise be deeply interested.

Modern investigations into the nature of the ether; into general electrical theory; and into the methods by which the whole domain of radiation has become merged into the general theory of electromagnetism, are cases in point. The same thing applies in the case of many practical problems which arise in dealing with such subjects as the distribution of power by means of polyphase currents, or transmitting signals by etheric telegraphy.

Those who have felt this want will warmly welcome a work like the present one, which will make it possible for any reader of ordinary intelligence, and having the elementary knowledge of the calculus which every engineering or physical student is now expected to possess, to follow, without serious difficulty, by far the larger number of the original investigations of the character above referred to, and certainly any of the treatises in which such results are systematically set forth.

Riemann's lectures, on which this work is founded, were originally published some forty years ago, and after his death three more editions with but little alteration were brought out by Karl Hattendorff. In this form it was confined mainly to the consideration of Fourier's theorem, and its applications to the solution of problems in the flow of heat, the elasticity of solid bodies, and irrotational hydrodynamics. Riemann's original papers offered great difficulties, even to able mathematicians; but in these lectures he expounded the subjects dealt with, which are usually regarded as difficult, with a clearness and simplicity which made them almost easy reading, even to the beginner.

More than two-thirds of the matter in the two volumes now under consideration has been added by Professor Weber, and he has done his work so well that a reader who was not familiar with the work in its earlier form would find it impossible to separate Professor Weber's additions from the original matter of Riemann's lectures.

The first volume contains three divisions—viz. Analytical Methods; Fundamental Geometrical and Mechanical Propositions; and Electricity and Magnetism. The first of these opens with the consideration of the definite integrals required for the Fourier analysis. The theorem is then proved and its limits strictly investigated. After this follows the consideration of volume and surface integrals with the theorems of Gauss and Stokes, a chapter on complex functions and their uses, and another on differential equations of the types which chiefly occur in physical problems. The theory of Bessel's functions, which play so important a part in problems of electric flow in wires and cables, brings the first division to a close.

The second begins with a chapter on infinitely small linear deformations; and is followed by one on vectors, in which the terms "curl" and "divergence" are explained; and lines of force, stream lines and vortex filaments, together with simply and multiply connected regions are considered.

Two chapters are devoted to the consideration of potential, and one to Laplace's functions—or, as Lord Kelvin calls them, spherical harmonies. The second division closes with a most valuable chapter on the fundamental principles of mechanics, including the principle of virtual work, D'Alembert's principle, the conservation of energy, the principle of least action, and Lagrange's generalised equations of dynamics. We have given in some detail the contents of this portion of the work, as, within the narrow limits of 301 pages, it gives a thoroughly intelligible and interesting exposition of the principal analytical methods of modern dynamics, and the reader who takes the trouble to master their contents will find very few memoirs or treatises on mathematical physics which he is debarred from grappling with on account of insufficient mathematical knowledge.

The second volume comprises five divisions. The first of these contains four chapters dealing with the hypergeometric series and other functions of use in solving certain differential equations occurring in the theory of elasticity, in the treatment of sound vibrations, etc. This portion is of far less general application than the analytical methods set forth in the first volume, and will be omitted by many readers. The four remaining divisions of the second volume deal with heat-conduction, the theory of elasticity, electric waves, and hydrodynamics, including Riemann's theory of air waves of finite amplitude. A good index at the end of the second volume makes the work handy for reference.